TRANSLATING PROJECT COMPLEXITY INTO AWARD CRITERIA; THE BALANCE OF QUALITY AND PRICE

A case study analysis into the use of award criteria in the procurement of replacement & renovation projects at ProRail

By

C.M.F. van der Feltz

TU Delft

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In partial fulfilment of the requirements for the degree of:

Master of Science in Construction Management & Engineering

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Preface

Before you lies the master's thesis titled "Translating project complexity into award criteria". From September 2024 to June 2025, I have been researching the world of procurement. My interest in infrastructure procurement began during the Construction Technology course within the Engineering & Systems track of the master Construction Management & Engineering. During this course, we worked in groups on a bid for a fictitious tender. During that course, I became more interested in tender processes. Although the subject was new, I quickly became fascinated by how contracts are awarded by a client to a contractor. I wanted to know more about the mechanism called "award criteria".

I have always been interested in the construction industry, whether it is about infrastructure construction, project development or interior architecture. Working on a tangible end result gives me great satisfaction. By completing these 9 months, I have learned a lot in the field of infrastructure procurement.

Of course, this learning process wouldn't be so valuable without the help of some people. First of all, I want to thank my supervisors Hans Ramler, Ad Straub and Evelien Bruggeman for their guidance and support during this thesis period. You helped me stay focused and guided my research in the right direction, especially when I sometimes lost the overview. In addition I would like to thank my company supervisor Cedric Otten. During my time at the tender strategy department of BAM Infra, I learned a lot from you. Thank you for the moments when you took the time to discuss the issues I was running into and to challenge me during my thesis.

I would also like to thank all my other colleagues at BAM who welcomed me into their organization and shared a lot of interesting knowledge with me. Besides that I want to thank all the interview participants and in particular Maarten de Wilde for sharing his knowledge and facilitating the interviews at ProRail.

Finally, I would like to thank my family, girlfriend and friends for listening to me and at least pretending to be interested in my stories. Whether I was making good progress or struggling at times, they were always there for me. These moments have been important during my graduation and for that I am very grateful to you!

Enjoy reading!

Christiaan van der Feltz

Management summary

As the manager of the Dutch railway infrastructure, ProRail faces a growing challenge in maintaining and upgrading its network through Replacement & Renovation (R&R) projects. These projects are becoming increasingly complex, due to technical uncertainties, organizational constraints, and numerous stakeholders. In public procurement for such projects, ProRail uses the Most Economically Advantageous Tender (MEAT) approach where bids are evaluated not just on price but also on quality through quality award criteria. These award criteria are the qualitative factors (besides price) on which contractors compete, and they allow the client to steer the market towards higher-quality bids rather than lowest-cost bids. ProRail's award criteria can be categorized into two types: ambition-driven criteria, related to the organization's broad policy goals (such as sustainability or safety), and complexity-driven criteria, tailored to the unique risks or objectives of a specific project. In practice, ProRail includes ambition-driven criteria in nearly every tender, whereas project-specific award criteria are applied only when the complexity of the project makes their use appropriate.

Problem statement
As R&R projects become more complex, successful project delivery requires a shift in procurement approach from lowest price towards most suitable in managing complexity-related risks. Public authorities should prioritize project-specific award criteria over price and ambition-driven award criteria. A misalignment between the project complexity and the use of award criteria can result in not selecting the most suitable contractor for delivering a successful project. While literature indicates that complex projects require a more tailored procurement approach, limited empirical research has focused on to what extent project-specific complexity is translated into the use of award criteria, especially in the context of Replacement & Renovation projects.

Therefore, the objective of this research is to formulate recommendations for public clients to translate project complexity in R&R projects into award criteria that enable contractors to distinguish themselves. The central research question is: *To what extent is the complexity of Replacement & Renovation (R&R) projects at ProRail reflected in the award criteria?*

Method
To address this question, a literature research was conducted followed by an empirical study at ProRail. The empirical study focused on four recent R&R tenders, each for which the MEAT procurement approach was used and project-specific award criteria were selected. For each tender, quantitative data (tender document analysis) about the use of award criteria was linked with qualitative data (semi-structured interviews) on the perceived project complexity. This method made it possible to analyze whether the perceived project complexity is in line with the use of complexity-driven award criteria.

Results
In projects 1 and 2, only about 27–30% of the total quality weighting was assigned to criteria that were project-specific. The remaining weighting was based on ambition-driven award criteria or price. Although complex elements were mentioned for these projects, they were viewed as relatively straightforward. For project 1, indeed the award decision placed heavier emphasis on ambitions and price rather than unique project risks. Project 2, the focus was slightly more on the project complexity, however price still remained the decisive factor in this tender.

By contrast, project 3, which was considered more complex, had approximately 40% of its quality evaluation dedicated to project-specific criteria. This project was perceived more complex due to greater uncertainties regarding asset condition and project scope, stakeholder management and time constraints. Project 4 was perceived as highly complex by both client and contractor, and almost the entire quality weighting was based on project-specific (complexity-driven) criteria. This demonstrates a positive relationship: the more complex the project, the greater the emphasis on complexity-driven award criteria.

Furthermore, the research found that technical complexity was rarely directly translated into award criteria. ProRail tends to address technical aspects through strict contract requirements and specifications, leaving little flexibility for contractors to propose alternative technical approaches. Instead, the award criteria mostly focused on organizational and environmental complexity, such as minimizing disruption for operators and for the environment.

Lastly, the contractor interviews revealed that many of ProRail's quality criteria offer little room for distinction, due to a few reasons: the specifications and requirements narrow the "solution space" and the award criteria evaluation methods limit the distinctive capability. This insight strengthens the study's findings and contributes to understanding how the weighting of complexity-driven award criteria influences the procurement outcome in practice.

Conclusion and recommendations

This research shows that the use of complexity-driven award criteria tends to be in line with the perceived level of complexity in R&R projects at ProRail. Simpler R&R projects place less weight on project-specific criteria and rely more on ambition-driven criteria and price. In contrast, more complex projects increasingly include project-specific award criteria that reflect unique project objectives or risks.

Nevertheless, not all dimensions of complexity are reflected in the award criteria. In particular, technical complexity is often handled through strict requirements. The decision to include complexity-driven criteria depends not only on whether the project team wishes to challenge contractors on specific risks, but also on whether the organization is open to distinctive proposals. This is particularly relevant in the highly regulated railway sector. Based on the four analyzed tenders, ProRail's approach shows a positive relationship between perceived project complexity and the use of tailored award criteria. Still, improvements are needed to ensure that such criteria have sufficient impact on the final award decision.

To improve the effectiveness of using complexity-driven award criteria, two recommendations are proposed. First, ProRail should refine its evaluation methods to enable more differentiation. This includes using more discriminating scoring techniques and setting higher performance thresholds to ensure that high-quality proposals are well rewarded and that not all bidders achieve more or less the same quality scores. Second, clearer communication is essential. ProRail should communicate more transparently to the market what their intention is behind each award criterion, as well as the broader objectives of the project. This helps contractors to better align their strategies with the client's expectations. It also ensures that contractor efforts are directed towards the priorities of the client. These recommendations would improve the contractor selection process by placing greater emphasis on quality rather than on price.

Management summary (NL)

Als beheerder van de Nederlandse spoorweginfrastructuur staat ProRail voor de groeiende uitdaging om het spoorwegennet te onderhouden en te vernieuwen via vervangings- en renovatieprojecten (V&R). Deze projecten worden steeds complexer door technische onzekerheden, organisatorische beperkingen en de betrokkenheid van diverse stakeholders. In de aanbesteding van zulke projecten past ProRail het principe van de Economisch Meest Voordelige Inschrijving (EMVI) toe, waarbij inschrijvingen niet alleen op prijs maar ook op kwaliteit worden beoordeeld via gunningscriteria. Deze gunningscriteria vormen de kwalitatieve aspecten waarop inschrijvers zich kunnen onderscheiden, en stellen de opdrachtgever in staat de markt te sturen richting kwalitatief betere aanbiedingen in plaats van enkel concurrentie op prijs. De gunningscriteria van ProRail kunnen worden verdeeld in twee typen: ambitie gerelateerde criteria, die aansluiten op bredere beleidsdoelen van de organisatie (zoals duurzaamheid of veiligheid), en complexiteit gerelateerde criteria, die specifiek zijn toegespitst op de unieke risico's of doelstellingen van een project. In de praktijk past ProRail vrijwel standaard de ambitie gerelateerde criteria toe in aanbestedingen. Project-specifieke gunningscriteria worden alleen gehanteerd wanneer de aard en complexiteit van het project daar aanleiding toe geven.

Probleemstelling
Nu V&R-projecten steeds complexer worden, vereist het realiseren van een succesvol project een verschuiving in de aanbestedingsstrategie: van laagste prijs naar geschiktheid in het beheersen van complexiteit gerelateerde risico's. Publieke opdrachtgevers zouden voor complexe projecten prioriteit moeten geven aan project-specifieke gunningscriteria in plaats van aan prijs. Een mismatch tussen projectcomplexiteit en de gebruikte gunningscriteria kan ertoe leiden dat de meest geschikte aannemer voor het uitvoeren van het project niet wordt geselecteerd. Hoewel uit literatuur blijkt dat voor complexe projecten een meer op maat gemaakte aanbestedingsstrategie de voorkeur heeft, is er beperkt empirisch onderzoek gedaan naar de mate waarin projectcomplexiteit daadwerkelijk wordt vertaald in de toepassing van gunningscriteria, met name in de context van vervangings- en renovatieprojecten.

Het doel van dit onderzoek is het formuleren van aanbevelingen aan publieke opdrachtgevers om projectcomplexiteit in R&R-projecten te vertalen naar gunningscriteria waarop opdrachtnemers zich kunnen onderscheiden. De centrale onderzoeksvraag luidt dan ook: *In hoeverre wordt de complexiteit van vervangings- en renovatieprojecten bij ProRail vertaald naar gunningscriteria?*

Methode
Om deze vraag te beantwoorden is eerst literatuuronderzoek uitgevoerd, gevolgd door een empirische studie binnen de context van ProRail. In deze studie zijn vier recente R&R-aanbestedingen geanalyseerd, waarin telkens het EMVI-principe werd toegepast en project-specifieke gunningscriteria waren opgenomen. Voor elk project zijn gegevens uit de aanbestedingsdocumenten (kwantitatief) gecombineerd met kwalitatieve data uit semigestructureerde interviews over de ervaren projectcomplexiteit. Deze methodiek maakte het mogelijk om te analyseren in hoeverre de waargenomen projectcomplexiteit in lijn was met het gebruik van complexiteit gerelateerde gunningscriteria.

Resultaten
De analyse van de toegepaste gunningscriteria en de ervaren projectcomplexiteit toont aan dat ProRail complexiteit slechts gedeeltelijk vertaalt naar project-specifieke gunningscriteria, maar dat de mate van vertaling in grote lijnen overeenkomt met de complexiteit van het project. In projecten 1 en 2 werd slechts 27–30% van de kwaliteitsweging toegekend aan project-specifieke criteria; de rest bestond uit ambitie gerelateerde criteria en prijs. Hoewel ook hier sprake was van complexiteit, werden deze projecten als relatief overzichtelijk beschouwd. Bij

project 1 lag de nadruk duidelijk op beleidsdoelen en prijs, terwijl bij project 2 iets meer aandacht was voor projectrisico's, maar prijs alsnog doorslaggevend was.

Daarentegen werd bij project 3, dat als complexer werd ervaren vanwege onzekerheden in scope, conditie van assets, stakeholdermanagement en tijdsdruk, circa 40% van de kwaliteitsweging toegekend aan project-specifieke criteria. Project 4 werd zowel door opdrachtgever als opdrachtnemer als zeer complex beschouwd; hier was vrijwel de volledige weging van kwaliteit gebaseerd op complexiteit gerelateerde gunningscriteria. Dit wijst op een positieve relatie: hoe complexer het project, des te groter het aandeel project-specifieke gunningscriteria.

Daarnaast blijkt uit het onderzoek dat technische complexiteit zelden direct wordt vertaald naar gunningscriteria. Technische risico's worden bij ProRail doorgaans beheerst via strikte eisen en contractuele bepalingen, wat weinig ruimte laat voor alternatieve technische voorstellen van aannemers. In plaats daarvan richten de gunningscriteria zich vooral op organisatorische en omgevings-complexiteit, zoals hinderbeperking en stakeholdermanagement.

Tot slot bleek uit de interviews met aannemers dat veel van de gehanteerde kwaliteitscriteria weinig ruimte laten voor onderscheidend vermogen. Enerzijds doordat technische specificaties de oplossingsruimte beperken, anderzijds doordat beoordelingsmethoden het lastig maken om op kwaliteit daadwerkelijk onderscheidend te zijn. Deze bevinding versterkt het belang van zorgvuldige invulling en beoordeling van gunningscriteria om in de praktijk impact te kunnen maken op de gunningsbeslissing.

Conclusie en aanbevelingen

Uit het onderzoek blijkt dat het gebruik van complexiteit gerelateerde gunningscriteria in aanbestedingen bij ProRail in grote lijnen in verhouding staat tot de ervaren projectcomplexiteit. Eenvoudigere R&R-projecten bevatten relatief weinig project-specifieke criteria en zijn meer gericht op beleidsdoelen en prijs, terwijl bij complexere projecten meer nadruk ligt op specifieke risico's en doelen. Niet alle vormen van complexiteit worden echter vertaald naar gunningscriteria; met name technische complexiteit wordt voornamelijk verwerkt via contractuele eisen. De keuze om specifieke criteria op te nemen is afhankelijk van de bereidheid van het projectteam om risicobeheersing bij de markt neer te leggen én afhankelijk van de interne acceptatie van onderscheidende voorstellen. Dit laatste is extra relevant in de sterk gereguleerde spoorsector. Op basis van de vier geanalyseerde projecten is sprake van een positieve relatie tussen de ervaren complexiteit en het aandeel project-specifieke gunningscriteria. Desondanks zijn verbeteringen nodig om ervoor te zorgen dat deze criteria daadwerkelijk invloed hebben op de gunningsbeslissing.

Om de effectiviteit van complexiteit gerelateerde gunningscriteria te vergroten, worden twee aanbevelingen gedaan. Ten eerste zou ProRail haar beoordelingsmethoden moeten aanscherpen om meer onderscheidend vermogen mogelijk te maken. Dit kan door toepassing van onderscheidende scoringsmethoden en hogere prestatiedrempels, zodat niet alle inschrijvers vergelijkbare scores behalen. Ten tweede is heldere communicatie essentieel. ProRail zou transparanter moeten communiceren over de bedoeling van elk gunningscriterium en de bredere projectdoelstellingen. Dit helpt inschrijvers om hun strategie beter af te stemmen op de verwachtingen van de opdrachtgever en voorkomt dat inspanningen worden geleverd op minder relevante onderdelen. Deze aanbevelingen dragen bij aan een betere selectie van opdrachtnemers, waarbij kwaliteit en geschiktheid meer centraal staan dan prijs.

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1. Introduction

The construction sector in the Netherlands is undergoing a significant change. After World War II, a substantial amount of infrastructure was built, designed with a specific technical lifespan. Many of these assets are now reaching the end of their functional life (Sancisi-Vellekoop, 2022). Once this point is reached, assets must be renovated or replaced to maintain required safety levels and agreed-upon performance standards (RWS, 2022). In addition, much of the infrastructure is used more intensively than originally intended, which means that replacement or renovation is often required earlier than expected (Bleijenberg, 2021).

These developments contribute to a major replacement and renovation (R&R) task for the coming decades (Rasker et al., 2023). Across the Netherlands, the national government, 12 provinces, 342 municipalities, and 21 water boards are responsible for over 141,000 km of roads, 5,700 km of waterways, 7,000 km of railway, and tens of thousands of civil structures such as bridges, viaducts, locks, and pumping stations (Rasker et al., 2023). A large share of this infrastructure is due for renewal. According to a forecast by TNO, the total cost for infrastructure renewal and renovation up to 2100 is estimated at €260 billion (Rasker et al., 2023). Of this total cost, 23% is expected to be under the responsibility of the national asset managers Rijkswaterstaat and ProRail. This means that ProRail will play a major role in the national R&R task and is therefore the focus of this research.

In addition to the growing demand, R&R projects are becoming increasingly complex. Kemmer (2018) describes that refurbishment projects are inherently complex due to scope uncertainty, unforeseen conditions, and ongoing operational constraints, which require intensive coordination and tailored planning. Combined with increasing stakeholder involvement and evolving public values, it has become challenging to deliver a successful R&R project.

On behalf of the Ministry of Infrastructure and Water Management, ProRail is responsible for the construction, management, and maintenance of the 7,000 km railway network (ProRail, n.d.). In other words, ProRail is responsible for the R&R projects of the railway network. As these projects are publicly funded, the efficient use of resources and successful project delivery are essential to safeguard public values.

To award contracts, ProRail applies the MEAT (Most Economically Advantageous Tender) principle, which allows tenders to be evaluated not only on price, but also on quality through the use of quality award criteria. These criteria challenge contractors to offer high-quality proposals instead of focusing on lowest cost (PianOo, n.d.) and can be categorized into two types: ambition-driven criteria, related to the organization’s policy goals (such as sustainability or safety), and complexity-driven criteria, tailored to the unique risks or objectives of a specific project. In practice, ProRail includes ambition-driven criteria in nearly every tender, whereas project-specific award criteria are applied only when the complexity of the project makes their use appropriate.

A key concern, however, is whether the award criteria used in each tender actually reflect the complexity of that project. If a highly complex project is assessed primarily through generic or ambition-driven criteria, this can result in not selecting the most suitable contractor for delivering a successful project. Despite the growing importance of this issue, little empirical research focused on how public clients, such as ProRail, translate project complexity into award criteria. Therefore, this study investigates to what extent the complexity of R&R projects at ProRail is reflected in the applied award criteria. This study is a starting point for further academic research on the relationship between project complexity and the use of award criteria in public procurement.

1.1 Problem definition

Renewal and Replacement (R&R) projects in the Dutch railway sector are becoming increasingly complex due to technical challenges, organizational constraints, and the involvement of multiple stakeholders with different interests. This complexity creates significant execution risks, which can be mitigated if contractors are selected based on their capability to manage these risks.

However, in the procurement strategy of public authorities, award criteria often focus on general ambitions instead of project-specific complexity. As a result, contractors may be incentivized to compete on price or generic quality criteria instead of demonstrating their ability to manage project-specific risks. Without a clear link between complexity and award criteria, there is a risk that projects are awarded to the lowest bidder rather than the most capable one for the execution of complex projects.

Despite literature on infrastructure renewal (Bleijenburg, 2021), there is limited empirical research on to what extent project complexity is translated into award criteria in Dutch public procurement. This research gap hinders the development of procurement strategies to align contractor selection with specific project risks in R&R projects. Addressing this gap is important to ensure a focus on minimizing project risks and encourage competition based on quality rather than solely on price.

1.2 Research objective and questions

The objective of this research is to formulate recommendations for public clients to translate project complexity in replacement and renovation projects into award criteria that enable contractors to distinguish themselves. Therefore, this research explores to what extent the complexity of R&R projects at ProRail is reflected in award criteria for the procurement of these projects. The insights into the use of award criteria at ProRail may be of interest to both contractors and other public authorities. Because the aim of this research is to discover to what extent project complexity is translated into award criteria by ProRail, the following main research question has been formulated:

To what extent is the complexity of Replacement & Renovation (R&R) projects at ProRail reflected in the award criteria?

To address this research question, the analysis is divided into sub-questions. The first three sub-questions are explored through literature research. Sub-question 4 to 7 are related to the case studies.

Part 1: Literature research

1. *What is the role of public authorities in R&R procurement? (Q1)*
2. *What is the role of award criteria in infrastructure procurement? (Q2)*
3. *What is the link between project complexity and award criteria in infrastructure procurement? (Q3)*

Part 2: Empirical study - ProRail (case studies).

4. *Which award criteria and corresponding weights are used by ProRail in R&R tenders that include project-specific quality components? (Q4)*

5. *Which technical, organizational, or environmental elements contribute to the complexity of R&R projects from ProRail's perspective? (Q5)*

6. *What is the contractor's perspective on project complexity in the R&R projects of ProRail? (Q6)*

7. *What considerations influence ProRail's selection of award criteria in R&R tenders? (Q7)*

1.3 Scope

The scope of this research is limited to R&R project tenders that use a MEAT (Most Economically Advantageous Tender) approach in the procurement process, where not only ambition-driven award criteria, but also project-specific award criteria are used. Therefore, an empirical case study is conducted for projects within one public authority, ProRail. Further research could compare the insights of this research with insights at different public authorities.

To answer the main research question, four projects were analyzed using a case study approach. This analysis provided insights into the award criteria applied, their relative weighting, and the types of project complexity they reflect. These findings contribute to a better understanding of the extent to which ProRail awards contracts based on a contractor's ability to manage complexity-related risks. While this method allows for in-depth exploration within a specific organizational context, it limits the generalizability of the results. The conclusions cannot be directly extended to other public clients or project types. However, the analytical approach used here can be replicated by other contracting authorities to evaluate their own tendering practices.

Furthermore, this research does not cover the full procurement process. The focus lies strictly on how award criteria are used in practice in the context of R&R projects. Aspects, such as suitability requirements do influence the use of award criteria. Increasing the number of requirements decreases the solution space for contractors, which influences the impact of quality criteria on the award decision. This is also mentioned in both the literature research and the discussion. However, this research does not focus on the link between project complexity and suitability requirements.

1.4 Relevance of the research

As mentioned in the report by Rasker et al. (2023), the Dutch national and local governments are facing a significant replacement and renovation (R&R) task in the coming decades. Renewing infrastructure is essential to safeguard accessibility, safety, and livability in the Netherlands. As Mark Harbers, Minister of Infrastructure and Water Management (2022–2024), stated: "Accessibility is the lifeline of our country and a prerequisite for a nation where it is pleasant to live."

For a successful project delivery, it is important to align the capabilities of contractors with the increasing complexity of R&R projects. Procurement strategies based solely on the lowest price are unlikely to award contracts to the contractor that is most capable of managing project complexity. Therefore, for complex projects, contracts should also be awarded based on award criteria that challenge contractors in how to manage project complexity.

This research investigates ProRail's use of award criteria (empirical findings) and compares it with insights from academic sources (literature findings).

1.5 Thesis outline

The figure below shows the structure of this thesis. First, a literature review is conducted to explore how project complexity can be translated into award criteria. Based on these insights, a conceptual model is developed that visualizes the connection between organizational ambitions, project complexity, and the selection of award criteria. Next, an empirical study is carried out using case studies from ProRail. This part includes a description of the research methodology, followed by the results of the case analysis and cross-case comparison. Finally, the discussion section reflects on the findings and highlights the limitations of the research. The conclusion provides answers to the main and sub-research questions and includes recommendations for practice and future research.

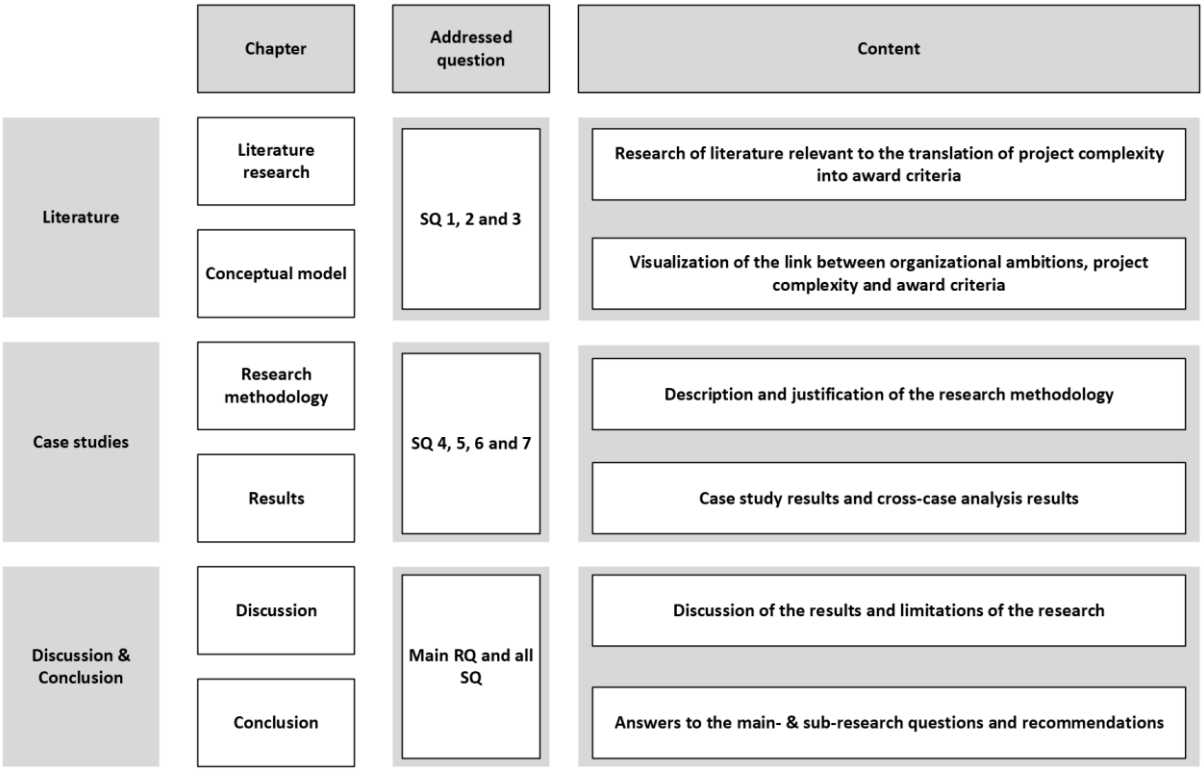

Figure 1: Thesis outline (own figure, Visio)

As presented in figure 1, this study consists of three parts: literature (1), case studies (2) and discussion and conclusion (3). The answers on sub-questions 1, 2 and 3 can be formulated by conducting a literature study. The answers on sub-questions 4, 5, 6 and 7 can be formulated by conducting document analyses and semi-structured interviews within the case studies. Finally, the answer on the main research question can be formulated by merging answers on the sub-questions.

1.6 Glossary

Ambition-driven award criteria: Quality award criteria (in MEAT approach), which are related to ambitions of an organization. These could either be applied to all tenders (policy) or applied to specific tenders when applicable.
Best Value Procurement (BVP): A procurement approach that focuses on selecting the contractor that delivers the best value, rather than just the lowest price. It emphasizes performance, risk management, and added value.
Bouwteam contract: A two-phase collaborative contract in which the client and contractor jointly develop the project design and execution plan before the actual construction begins.
Complexity-driven award criteria: Quality award criteria (in MEAT approach), which are related to project specific goals that are related to project complexity. In this research the TOE-framework is used to distinguish between technical, organizational and environmental complexity.
CO_2 performance ladder: A sustainability certification system used in Dutch procurement. Contractors with higher levels (so-called “steps”) on the ladder may receive advantages during tender evaluation, rewarding efforts to reduce carbon emissions.
Kraljic matrix: A strategic procurement model that classifies purchases (or projects) based on supply risk and strategic importance. It helps organizations determine the most suitable procurement strategy per category.
MEAT (Most Economically Advantageous Tender): A procurement method that balances price and quality, awarding the contract not solely to the lowest bidder but to the bid with the best price–quality ratio.
Invitation to tender (Aanbestedingsleidraad): The main tender document that provides bidders with instructions, background, evaluation criteria, and procedural information for submitting their proposal.
Safety Culture Ladder (SCL): A certification system used to assess the safety culture within companies. A higher level indicates more proactive and embedded safety practices.
Recognition scheme (Erkenningsregeling): A prequalification system used by ProRail, allowing only certified contractors to participate in tenders. It replaces the standard selection phase and aims to ensure competence and reliability.
R&R projects (Replacement & Renovation): Infrastructure projects focused on replacing or renovating assets, typically involving high complexity due to existing usage, integration with legacy systems, and limited downtime availability.
TOE-framework: A complexity framework that categorizes project complexity into Technical, Organizational, and Environmental factors. It is used to assess which elements could contribute to the complexity of a project.
UAV-GC contract: A Dutch standard for integrated contracts (Uniforme Administratieve Voorwaarden voor Geïntegreerde Contracten), commonly used for design and construct projects. It places more responsibility on the contractor.
Zero Emission: This award criterion challenges contractors to operate with Zero Emission equipment to minimize the environmental impact of the project.

2. Literature Research

This chapter outlines the literature research that forms the foundation of this study. It presents the relevant topics related to the use of award criteria in the procurement of replacement and renovation (R&R) projects and the role of award criteria in the procurement process. By examining relevant literature, this chapter aims to provide a comprehensive understanding of the relevant topics to in the end introduce the knowledge gap and research that will be described in the research methodology. In the underlying figure, the concepts that are described in this chapter are visualized.

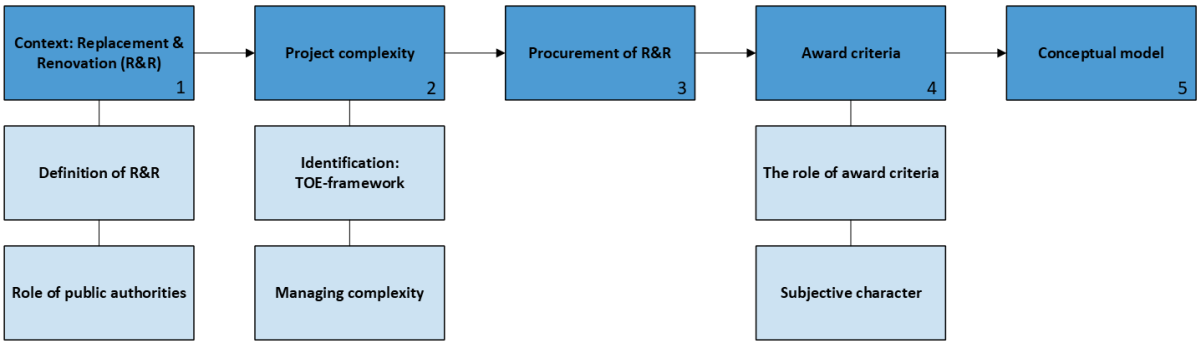

Figure 2: Structure of the literature research

Part 1 describes the context of this research. The context of this research is the need for carrying out Replacement & Renovation (R&R) projects. The definition of R&R projects helps to scope the research and guides the selection of projects for the case studies. Next, the role of public authorities in addressing the R&R challenge is explained. Part of this section is the specific role of ProRail.

Part 2 describes literature related to project complexity. To formulate an answer on to what extent project complexity is translated into award criteria, the vague term complexity should be defined first. Within this part, the TOE-framework (Bosch-Rekveldt et al., 2011) is reviewed to categorize project complexity. Project complexity is often cited as a contributing factor to project failure, such as cost overruns and delays (Williams, 2005, Williams, 2013). Therefore managing project complexity is highly relevant. This section is the link between project complexity and the procurement of R&R projects, which is described in part 3.

Part 4 describes literature related to award criteria, being a mechanism that is used in infrastructure procurement. First, the role of award criteria is described, followed by a section about the subjective character of award criteria. The conceptual model in part 5 summarizes the literature review of this chapter and is the starting point for the case studies.

2.1 Replacement & Renovation projects in Dutch infrastructure

In the first part of this literature research, the context of Replacement & Renovation (R&R) is described. This subchapter focuses on the role of R&R projects within infrastructure asset management. To establish a clear scope for this research, it is essential to define what R&R entails and describe the importance of maintaining the functionalities and safety of infrastructure.

2.1.1 Definition of replacement and renovation (R&R)

As mentioned in the introduction, much of the existing infrastructure is due for replacement or renovation. The term Replacement and Renovation (R&R) was introduced by public authorities. For R&R, the following definition is used:

Infrastructure assets for which safety and/or functionality can no longer be ensured through regular Management & Maintenance due to the end of their lifespan (de Lange, 2016).

Regular Management & Maintenance (M&M) consists of planned measures implemented from the start of infrastructure use to maintain its functionality throughout the intended lifespan. This process involves regular small-scale activities (de Lange, 2016). However, the need for R&R arises when regular M&M is no longer sufficient to ensure legally required safety levels or agreed-upon performance standards due to aging infrastructure (RWS, 2022). The transition from M&M to R&R occurs when the end of the technical lifespan is reached.

Therefore, R&R can be defined as the maintenance that should be carried out when the end of technical lifespan is reached. For complex infrastructure assets, such as tunnels, this definition applies not only to the overall structure but also to individual components of that structure. For instance, the end of the lifespan of tunnel technical installations can necessitate R&R measures for the entire tunnel (RWS, 2022). The necessary measures to maintain the structure then become far more extensive than anticipated in the SLA BOO (Service Level Agreement Beheer, Onderhoud en Ontwikkeling). According to Bleijenberg (2021), causes for reaching the end of the technical lifespan include:

- Normal aging, resulting in significant technical deficiencies.
- Changed usage, which accelerates technical deficiencies, such as increased load due to heavier traffic.
- Unsupported technologies, which makes maintenance of the asset impossible or only feasible at very high costs. For example, when replacement or spare parts are no longer available.
- Changes in standards, which modify the assessment of an asset's suitability for use, for example, when an asset no longer meets new structural safety standards.

Management & maintenance is part of infrastructure asset management. Effective asset management is crucial to maintain the functionality of infrastructure (Schraven et al., 2011). In addition, infrastructure should not only be functional and reliable but also future-proof, safe, and sustainable. To achieve these objectives, a continuous balance is required between renovating and replacing existing infrastructure.

A well-structured asset management plan will optimize the performance and extend the lifespan of infrastructure assets.. Nevertheless, infrastructure is designed with a specific technical lifespan, and a time will come when R&R is needed to preserve its functionality (Rasker et al., 2023). This moment of intervention is referred to by Rasker et al. as the *renewal*

challenge, the point at which maintenance is no longer sufficient, and structural upgrades or full replacement are required.

In their report, ProRail is identified as one of the largest infrastructure owners in the Netherlands. This public organization assesses the technical condition of its assets based on three key indicators: lifespan, reliability, and safety (Rasker et al., 2023). These indicators apply to various elements of the railway system, including tracks, switches, bridges and tunnels, level crossings, power supply, train control systems, and substructure. It was noted that ProRail is responsible for 48.59% of the total surface area of tunnels and underpasses in the Netherlands (Rasker et al., 2023).

The definition of R&R provides a contextual framework to select the projects that are analyzed in this research. This research only focuses on projects that fall within this definition of replacement and renovation, with the assumption that R&R projects include a specific project complexity that is different than new construction. Therefore, this study aims at analyzing to what extent the project complexity of R&R projects of ProRail is translated into award criteria.

2.1.2 Role of public authorities in infrastructure Replacement and Renovation

(Semi-)public clients play a significant role in shaping the built environment and are responsible for a large share of the construction works in the Netherlands. They are expected to actively contribute to innovation while ensuring that public funds are spent properly (Kuitert et al., 2019). This highlights the importance of a well-considered price–quality ratio in the procurement of infrastructure projects.

Public authorities outsource infrastructure projects to contractors. In doing so, public clients must balance two roles: ensuring efficient and effective project delivery through the market, while at the same time safeguarding public values (Kuitert et al., 2019). This dual responsibility makes public commissioning a strategic activity, in which procurement choices serve as key instruments for achieving broader policy objectives. And precisely efficient and effective spent of public funds is important in the Replacement and Renovation of infrastructure in the Netherlands, as there is more work to do than capacity in the market (Rasker et al., 2023). This efficient and effective spent is regulated through procurement (PianOo, n.d.).

A working paper by Weijnen et al. (2015) describes that infrastructure is about basic services that are essential for everyone and almost all social and economic activities in society. Therefore, efforts are made to ensure that public values are safeguarded in the delivery of infrastructure products and services. The most prominent public values that apply to all infrastructures are: accessibility, affordability, availability and social acceptability, also known in the literature as the four A's: Accessibility, Affordability, Availability and Acceptability (Borges, 2012).

In particular, availability and social acceptability align with the replacement and renovation task in the Netherlands. Social acceptability covers a range of public values, ranging from safety, health and environmental concerns to equity and respect for privacy (Weijnen et al., 2015). Indeed, as described in the forecast by Rasker et al. (2023), investments by public clients will have to increase substantially in the coming years to ensure infrastructure accessibility and safety.

2.1.3 Role of ProRail

The Ministry of Infrastructure and Water Management (I&W) is responsible for laws, rules and policy on railway use. The ministry also grants concessions for passenger transport on the main railway network and for railway management. The ministry finances the construction and most of the maintenance of the railway network. On behalf of the Ministry of Infrastructure and Water Management, ProRail is responsible for (Ministerie van IenW, 2018):

- constructing, managing and maintaining railway infrastructure, including tunnels, level crossings, overhead lines, signs and points;
- managing and maintaining railway facilities, such as stations;
- allocating network capacity. ProRail runs the railway traffic control center and coordinates disaster response.

ProRail plays a vital role in connecting people, cities, and businesses through the Dutch railway network, now and in the future. Through continuous investment in maintenance and renewal, ProRail aims to provide comfortable travel, support sustainable transport, and safeguard safety on and around the railway system. Rail infrastructure is maintained continuously to meet the growing mobility needs of the future.

However, the current state of the railway infrastructure shows signs of deterioration. In a letter to the ministry, ProRail CEO Voppen (2024) reported a downward trend in the technical condition of the network. This development underlines the increasing importance of Replacement and Renovation (R&R) projects across the network. A challenge that is mentioned lies in the shortage of skilled technical personnel and the increasing scale of renewal demands. These two factors impact the difficulty of the planning and execution of maintenance and replacement works. As a result, there is a growing need to develop and improve procurement strategies to better align with market capacity and ensure that infrastructure projects are delivered efficiently and within available time windows.

Ambitions of ProRail

ProRail's ambition is to enable the Dutch economy and society to keep moving in a clean and sustainable way. In addition to carrying out its daily core tasks, ProRail focuses on the future of the railway system by facilitating the transport of more passengers and goods by rail. In doing so, it aims to provide a sustainable response to growing mobility demands while ensuring safety and reliability through continuous maintenance and project delivery (ProRail, 2024).

A central pillar of this ambition is sustainability. ProRail seeks to reduce its ecological footprint by lowering the energy and material consumption within its supply chain and limiting the impact on nature (ProRail, 2024). However, the realization of this ambition is challenged by practical constraints. According to the *Masterplan 2026–2030*, limited financial resources, shortages of technical personnel and materials, and restricted track availability due to ongoing operations and passenger needs all complicate project delivery. The ability to manage uncertainty and operate flexibly in a dynamic environment is becoming increasingly important (ProRail, 2024, p. 8).

ProRail plans its project portfolio based on the feasibility of the programmed works. To make this possible, ProRail must balance four capacities: available funding, market capacity (especially among contractors), acceptable disruption for passengers and freight users, and internal organizational capacity (ProRail, 2024, p. 8). Their Masterplan (2026-2030) highlights several critical points:

- Track closures (TVP) are difficult to reschedule due to interconnected planning (p. 28);
- There are projected peaks in required technician capacity for implementation (p. 29);

- The number of bids on large, complex tenders is decreasing, which highlights the need for early market engagement and better tender planning (p. 36);
- From 2027 to 2030, the volume of planned works exceeds acceptable disruption thresholds, and current optimization efforts are insufficient to prevent significant impact on users (p. 32). Customer disruption is measured via Key Performance Indicators (KPI): Extra Experienced Minutes (ERM) for passengers and Extra Freight Hours (EGU) for freight. These indicators have been developed in cooperation with operators such as NS, Arriva, and freight carriers (p. 30).

ProRail concludes that meeting future demand requires not only technical and organizational solutions but also innovative collaboration with contractors. The organization explicitly calls for letting go the traditional approaches and embracing new ways of working, both in terms of project content and procurement strategy (ProRail, 2024, p. 9).

2.1.4 Contextual summary

Given ProRail's central role in managing and renewing the Dutch railway infrastructure, the organization is responsible for delivering a growing number of Replacement and Renovation (R&R) projects under increasingly challenging conditions. The ambitions outlined in the Masterplan 2026–2030 (ProRail, 2024), such as minimizing disruption, working sustainably, and coping with capacity shortages in the market and within ProRail itself, all contribute to a highly complex project environment.

To better understand how these ambitions and constraints translate into procurement decisions, it is essential to first explore the concept of project complexity.

2.2 Project complexity

As highlighted in multiple studies, project complexity is often cited as a contributing factor to project failure, such as cost overruns and delays (Williams, 2005, Williams, 2013). Gaining better grip on project complexity could help prevent such failures. However, without a clear definition of complexity, it is difficult to get a better grip on it.

In 2009, Geraldi pointed out that the literature lacked a clear and unambiguous definition of project complexity or complexity in project environments. Also in 2009, Whitty & Maylor made a distinction between complicated and complex projects. Complicated projects consist of many interrelated components but can be managed using linear processes. These projects can be broken down into parts and addressed with established methodologies. In contrast, complex projects involve non-linear components that introduce uncertainty.

Refurbishment projects, in general, are widely recognized as being high risk, complex and uncertain (Ranasinghe et al., 2019). Ranasinghe et al. mention a number of reasons for this uncertainty, such as a lack of information about the existing structure and occupation throughout execution.

Refurbishment projects have different features in comparison with new build projects. This refers mainly to the fact that they are carried out in an existing asset that might remain in operation. Such characteristics increase the complexity inherent to construction settings (Kemmer, 2018). The most important features mentioned are:

- Additional level of uncertainty and variability, due to unforeseen conditions, an unclear project scope, and unavailable asset information.
- Operational challenges, due to the specific site area constraints, operational constraints and time constraints.
- Health and safety concerns, due to dangerous work and the interface with existing operations.

Although Kemmer's research focuses on building projects, the same characteristics are also relevant to infrastructure Replacement and Renovation (R&R) projects. Therefore, the refurbishment features as described by Kemmer (2018) can also be applied to R&R projects.

In addition to that, infrastructure is ageing and requires more investments in maintenance and upgrades in order to maintain existing performance levels. Infrastructure assets are characterized by long life and complex deterioration, and knowledge about the way these assets deteriorate over time and how the deterioration affects the costs, risks, and performance is patchy (Parlikad & Jafari, 2016). This is in line with the additional level of uncertainty as described by Kemmer. Thus, projects intended to refurbish infrastructure (R&R) often have a higher degree of complexity compared to new construction.

2.2.1 Link between project complexity and award criteria

An assessment of the inherent complexity of a project is usually a good indicator of how much latent uncertainty there is in the project (Cleden, 2009). According to Cleden (2009), the measure of project complexity depends on two things:

- the number of project elements;
- the number and nature of interactions between elements.

A large project has many different elements: many different tasks to be performed, deliverables to be produced, subcontractor inputs to be controlled, a large team to be managed, etc. But this is only one dimension of complexity: if these elements interact with each other and have non-trivial dependencies, it creates a complex set of interrelationships. Changes to one part of the system may have large or hard to predict consequences for other parts of the project (Cleden, 2009).

As the number of dependent tasks increases, a complex network of dependencies quickly develops (Cleden, 2009). In this way, tasks interact with each other. These interactions are not always sequential interactions, as for example in a production line. This is in line with the proposed definition of project complexity by Baccarini (1996). It proposed that project complexity can be defined as 'consisting of many varied interrelated parts' and can be operationalized in terms of differentiation and interdependency (Baccarini, 1996). This definition can be applied to any project dimension relevant to the project management process. Therefore, it is important to be clear about the type of complexity being dealt with.

Baccarini also mentioned that the meaning of complexity has a subjective connotation implying difficulty in understanding and dealing with an object (Baccarini, 1996). This implies that everyone has a different interpretation of complexity. This again implies that there could never be a theory that completely defines the complete set of elements that contribute to project complexity.

In 2011, Bosch-Rekveldt et al. tried to grasp project complexity by creating a framework of elements that contribute to project complexity. While the framework was originally designed for assessing complexity in the process engineering industry, it was later applied to the construction industry in a 2013 follow-up study by Bosch-Rekveldt. This shows that this framework could be used to assess project complexity in R&R projects.

In the original paper (2011), Bosch-Rekveldt et al. mention that project complexity is often considered to be caused by uncertainties. They refer to Perminova et al. (2008) for a new perspective on uncertainty in projects and how to manage uncertainties. Perminova et al. describe the link between uncertainties and risk management. They define uncertainty as “a context for risks as events having a negative impact on the project's outcomes, or opportunities as events that have beneficial impact on project performance.”

However, a paper by Vidal and Marle (2008) describes that uncertainty appears as one of the possibly negative consequences of project complexity. As a consequence, complexity-driven uncertainties are a major source of risks for the project (Vidal and Marle, 2008). In their paper, they describe that by paying attention to the key aspects of complexity that can be risky (for instance, some interfaces within the project system), the identification of this first class of complexity induced risks will enable one to complete the risk lists which are usually done thanks to traditional risk analysis methodologies.

Combining these two academic papers (Vidal and Marle (2008);Bosch-Rekveldt et al. (2011)) results in the risk - complexity loop, presented in figure 3. This loop describes that according to the theory of Vidal and Marle, complexity is a source of risk, where Bosch-Rekveldt et al.

describe risk as a contributor to complexity. For this research, the theory of Vidal and Marle is used to link complexity to risks. However, for the identification of elements that contribute to project complexity, the framework of Bosch-Rekveldt et al. is used.

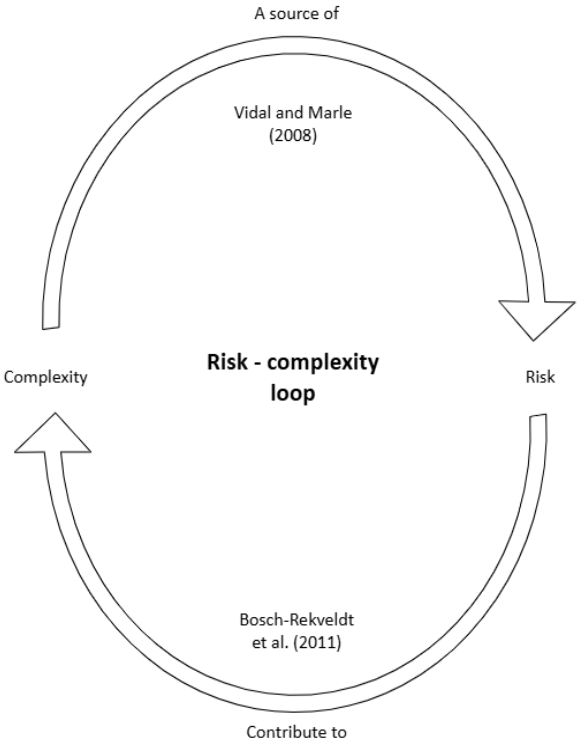

Figure 3: Risk complexity loop. Combining two theories (Vidal and Marle (2008) & Bosch-Rekveldt et al. (2011)) (own figure)

With increasingly complex projects, risk management becomes more important and risk management should be done throughout the whole life cycle of a project (Jaafari, 2001). Schieg (2006) describes that risk management consists of six steps. These steps are described in the following figure:

Figure 4: Risk management steps (Schieg, 2006)

The fourth step of risk management is risk control. Risk control consists of four methods to control the risk, which are avoidance, reduction, passing on the risk and bearing the risk by oneself (Schieg, 2006). This is in line with the four general risk response strategies: avoidance, acceptance, transfer and mitigation (PMI, 2000).

Risk transfer in procurement contracts can be described clearly in terms of how risks are managed within the contractual arrangements. A possible method to manage risks is by defining award criteria. Award criteria could be used to transfer risks, because promises made in the bid become contractual obligations after awarding of the contract. However, this is not always the main intention behind using award criteria. Clients often prefer to assess whether a contractor is capable of managing a specific risk, rather than just shifting the financial responsibility for that risk to the contractor.

Therefore, the link between project complexity and award criteria can be interpreted in two ways: in some cases, award criteria are used to transfer risks, while in other cases, the focus is on risk management without the intention of a risk transfer. The link between project complexity and award criteria, as described in this section, is visualized in figure 5.

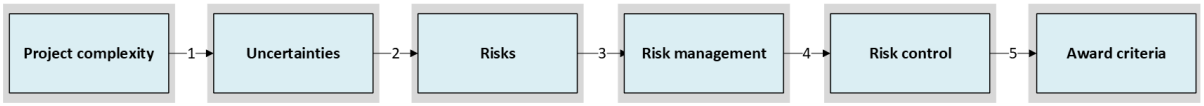

Figure 5: Visualization of link between project complexity and award criteria (own figure, Visio)

The numbered arrows correspond to literature studies that describe the link between the two boxes:

1. *Whitty & Maylor (2009):* Complex projects involve non-linear components that introduce uncertainty.
2. *Perminova et al. (2008):* Uncertainty is defined as "a context for risks as events having a negative impact on the project's outcomes, or opportunities as events that have beneficial impact on project performance". *Vidal and Marle (2008):* Uncertainty appears as one of the possibly negative consequences of project complexity.
3. *Jaafari (2001):* With increasingly complex projects, risk management becomes more important and risk management should be done throughout the whole life cycle of a project.
4. *Schieg (2006):* Risk control consists of four methods to control the risk, which are avoidance, reduction, passing on the risk and bearing the risk by oneself.
5. *Burke & Demirag (2017):* Multiple risks categories, for example planning risk and operational risk, could be transferred to the contractor.

2.2.2 Identification of project complexity: TOE framework

The TOE framework can be applied to create a footprint of a project's complexity. This footprint increases the understanding of the complex aspects of a project and provides potential handles to better manage the project (Bosch-Rekveldt et al., 2011). The framework contains elements categorized into three main categories and 14 subcategories.

This framework can be used to assess the complexity of projects in the case studies. Even though, some elements could contribute more to the complexity of renovation projects then to new construction projects, the framework could be used to get a grip on the complexity of the projects. Nevertheless, project complexity is project specific and has a subjective character. Therefore, the elements that contribute to complexity differ per project.

Subcategories of TOE.

Technical	Organizational	Environment
Goals	Size	Stakeholders
Scope	Resources	Location
Tasks	Project team	Market conditions
Experience	Trust	Risk
Risk	Risk	

Figure 6: Subcategories of TOE-framework (Bosch-Rekveldt et al., 2011)

Bosch-Rekveldt et al. mentioned that project complexity changes during the project life cycle. To grasp the dynamics of project complexity, the framework should be applied in various stages. However, when applied before the procurement of a project, the framework could be used to identify elements of a project that may contribute to complexity, and therefore risk strategies could be created. Elements can be identified and grouped together to map which elements are important to take into account. One of the limitations of the TOE framework is the qualitative character of the study (Bosch-Rekveldt, 2011). Mapping complexity is a subjective process, which makes it essential to involve multiple experts to ensure that all relevant elements are identified. Subjectivity also plays a role when applying this framework as a complexity identification tool. In appendix E, the elements of the TOE-framework are shown.

2.3 Managing project complexity

As mentioned in the first paragraph of this section, project complexity is often cited as a contributing factor to project failure, such as cost overruns and delays (Williams, 2005, Williams, 2013). In addition, Trinh and Feng (2020) discovered that the safety performance of a project gets negatively impacted by technical and environmental project complexity. Also, Luo et al. (2017) discovered that project complexity has a negative connection with project success, so to ensure project success, one must know how to manage project complexity. These studies emphasize the importance of project complexity management. One way to manage project complexity is by aligning the procurement approach and award criteria with the level and nature of project complexity (Eriksson, 2017; Baldi et al., 2016).

Baldi et al. (2016) found that an increase in project complexity raises the probability that a project will be procured through a negotiated procedure by approximately 6–8%. This demonstrates that contracting authorities in practice adjust their procurement strategies to match the complexity of projects. The reason for this shift lies in the greater flexibility that negotiated procedures offer for dealing with uncertainty and project-specific risks. In this context, award criteria become critical tools to select best suitable bids.

A price-only selection approach may not be effective for complex projects, as it fails to account for a contractor's ability to manage uncertainty-related risks. Instead, multi-dimensional award criteria (MEAT – Most Economically Advantageous Tender) are recommended to strike a balance between cost, quality, and risk (Baldi et al., 2016). These criteria allow public clients to reward the quality of a bid, rather than simply choosing the lowest bidder.

This is in line with Eriksson's (2017) findings, that suggests that small and simple projects with low uncertainty and limited resources should prioritize short-term efficiency through traditional procurement strategies, where large and complex projects with high uncertainty and customization benefit from an approach that combines exploration and exploitation to achieve sustainable performance. The strategy of small and simple projects includes fixed-price payment structures, and price-focused bid evaluations. However, the large and complex projects require collaborative procurement strategies such as early contractor involvement, cost reimbursement coupled with incentive-based payment models, multi-criteria bid evaluation, and the use of collaborative tools in partnership arrangements.

To align procurement strategies with project characteristics, the Kraljic Matrix (1983) could be used as a framework to categorize projects to decide which procurement method is the most suitable. The categorization is based on the impact of a project on the organization's operations and the complexity or risk of the supply market. Although this framework was originally developed for supply chain management, the matrix could be used to guide which types of projects require more strategic contractor relationships and for which projects efficiency or standardization should be prioritized.

Another strategy for managing project complexity is to define a clear project scope (Ahmed & Jawad (2022). However, in Replacement & Renovation (R&R) projects, this can be particularly challenging due to uncertainties in the asset's condition and lack of information (Kemmer, 2018). Unexpected structural deficiencies, outdated documentation/inspections, or unforeseen technical constraints can make it difficult to define the right scope for extending the lifetime of an infrastructure asset. In the report by Ahmed & Jawad (2022) it was pointed out that scope creep factors (i.e. technological, organizational, and human) negatively impact the success of construction projects. Furthermore, project complexity significantly moderates the relationship between scope creep and project success. Therefore, public authorities tend to apply award criteria to score bids on the capability of dealing with unexpected scope changes.

Complexity may also influence the choice of contract type (Gao et al., 2018). Empirical results show that contractual coordination can deal with risks induced by technical, organizational, and environmental complexity. The study identifies three contractual functions that can be used to mitigate complexity-related risks: contractual control (strict monitoring, penalties), contractual coordination (defining roles, responsibilities) and contractual adaptation, which allows flexibility in contracts to handle unforeseen circumstances.

When significant complexity is identified, contracts can be structured to better distribute risks. A possible approach is the use of two-phase contracts that are used to split the design process and the execution process. This separation allows contractors and clients to collaborate earlier in the design process and share the risks for that part. For these contracts, different award criteria could be used to emphasize collaboration and project approach more (PianOo, n.d.).

Emblemsvåg (2020) describes another risk management strategy that could be applied: a margin of safety approach. A margin of safety approach assumes that risk will probably occur and focuses on minimizing its impact rather than solely trying to predict it." Such a strategy could be particularly useful for R&R projects, where significant scope uncertainty often makes accurate pricing difficult.

In R&R projects, the main difference from new construction is that there is already an existing structure in use and part of the infrastructure system. Yang et al. (2018) mention that the integration of infrastructure within densely populated areas adds layers of complexity. This could also be applicable for projects of ProRail.

Overall, there are different ways to manage project complexity. Award criteria could be used to check whether a contractor is capable of managing complexity-related risks or they could be used to transfer these risks. The goal of using these award criteria is not always to just transfer the risk to the contractor, but to improve the chance of project success by evaluating whether a contractor could handle certain risks. For example, for public authorities it could be more important to deliver a successful project than to make sure they are not responsible for the costs of possible risks. Selecting the award criteria is part of the procurement process, so before zooming in on the role of these award criteria, the next section first describes the procurement of R&R projects and in particular procurement at ProRail.

2.4 Procurement of Replacement & Renovation projects

Similar to new construction projects, renovation and replacement (R&R) projects are procured through a tendering process. This process typically involves selection phase, in which a shortlist of qualified contractors is compiled based on predefined criteria, and an awarding phase, during which the most suitable contractor is chosen based on award. Since the revision of the Dutch Public Procurement Act in 2016, the use of the Most Economically Advantageous Tender (MEAT) approach has become the standard approach for European tenders and tenders under the Procurement Regulation for Public Works 2016 (ARW 2016). This means that tenders must consider both price and quality. Within this framework, quality-related criteria can be categorized as either ambition-driven award criteria, which reflect policy goals, or project-specific criteria, which address unique project goals of a particular project. A project goal could be minimizing risks.ar project.

Discretionary powers in defining award criteria provide contracting authorities with the flexibility to establish criteria that align specifically with the unique goals and requirements of the project (Bordalo Faustino, 2017). In R&R tenders, discretionary powers are especially important because each asset is embedded in a unique environment and therefore requires award criteria tailored to the risks or chances of the project.

Besides MEAT tenders, projects could also be awarded solely on price or solely on quality. Both these methods are only allowed in exceptional cases and must be clearly justified in the tender documents. When the requested scope is widely standardized and readily available on the market, significant differences in quality are not to be expected, and the content and scope of the assignment can be clearly defined, lowest price procurement is to be preferred (PianOo, n.d.). Also, in non-complex situations, when the costs of delivering different quality levels are well known and several firms have the ability to provide (close to) optimal quality, lowest price, being a simple and robust supplier selection method, is to be preferred (Bergman & Lundberg, 2013). However, awarding solely on price could have several disadvantages.

2.4.1 Disadvantages of lowest price procurement

Awarding contracts based on the lowest price brings several disadvantages, especially in complex infrastructure projects. Preda & Simion (2019) describe these disadvantages. They mention that awarding on lowest price often leads to poor quality outcomes, as contractors are pushed to cut costs, sometimes at the expense of performance. It also discourages innovation, since more advanced or smarter solutions usually come with a higher price and therefore don’t score well. Only innovations that reduce the costs on the long term are beneficial for contractors. In addition, it limits the contractor’s ability to stand out on quality, as bids tend to stick to the bare minimum of what is required. This makes it harder to select the most suitable contractor instead of the cheapest one. Another downside is that low-price strategies increase the risk of failure in projects with a lot of uncertainty, as the margins are low and risks are less taken into account in the pricing. Lastly, lowest price procurement only works when all technical specifications can be precisely defined upfront, which is often unrealistic in renovation or replacement projects.

Also, Bergman & Lundberg (2013) mention several concerns about using lowest price as the main award criterion in public procurement. Predominantly, it notes that when cost is prioritized over value, quality can suffer. Suppliers might cut corners, offer minimal compliance, or reduce innovation to remain competitive on price. This can lead to long-term inefficiencies, higher maintenance costs, or even project failure. The report suggests that MEAT (Most Economically Advantageous Tender) approaches are better suited in complex or service-oriented projects (Bergman & Lundberg, 2013).

2.4.2 Procurement process of ProRail

Within ProRail's infrastructure program, Replacement & Renovation (R&R) projects are classified under function preservation. Function preservation projects aim at maintaining a safe and reliable railway network. These projects make up a significant portion of the planned works for the 2026–2030 period (ProRail, 2024). For function preservation projects, ProRail applies the MEAT approach in its procurement process. Given the limited financial resources available for function preservation projects (ProRail, 2024), it is essential to achieve a careful balance between price and quality. This requires choices about which quality aspects should be prioritized in the evaluation process. Award criteria must therefore be formulated in a way that they contribute meaningfully to identifying the most suitable contractor, without unnecessarily increasing the project costs.

To ensure the efficient use of capacity of both client and contractor, it is not wise to have too many parties participating in the tender (Crucq & Bossink, 2011). Therefore, a selection phase could be included in the process to narrow down the pool of qualified candidates. To reduce transaction costs and ensure consistency in quality, ProRail uses a contractor qualification system (ProRail, n.d.). Only contractors who are approved under this system are eligible to tender. Currently, in total 8 railway contractors are approved by ProRail (ProRail, 2024). This could be considered a regulated oligopoly. This prequalification ensures that participants meet administrative, technical, and professional requirements. This streamlines the tender process, because the selection process is not necessary for each railway related project (ProRail, 2023).

This regulated structure also has implications for the competitiveness within the railway sector. The degree of specification in a tender strongly influences the extent to which contractors can distinguish themselves (PianOo, n.d.). When public clients define the scope and technical requirements in great detail, the solution space becomes smaller, which leaves little room for contractors to propose innovative or project-specific approaches. This reduces the effectiveness of MEAT criteria, as opportunities for differentiation are minimal. This is particularly relevant in ProRail's context, where technical specifications are often prescribed and the number of qualified contractors is small. This is elaborated more in figure 10 in the award criteria chapter.

Visualization of the award decision including complexity

Figure 7 visualizes the award decision, which is based either on quality, on price or a combination of quality and price (MEAT). Quality criteria are divided into ambition-related and complexity-related award criteria. The ambition-related award criteria are award criteria that are related to the ambitions of an organization and could be applied either as policy to all the tenders or applied for specific projects. An example of a policy award criterion is the Safety culture Ladder (SCL) and an example of a project specific ambition-related award criterion is the MKI. Complexity-related award criteria are award criteria that are project specific and in this model divided into award criteria related to either technical complexity, organizational complexity or environmental complexity.

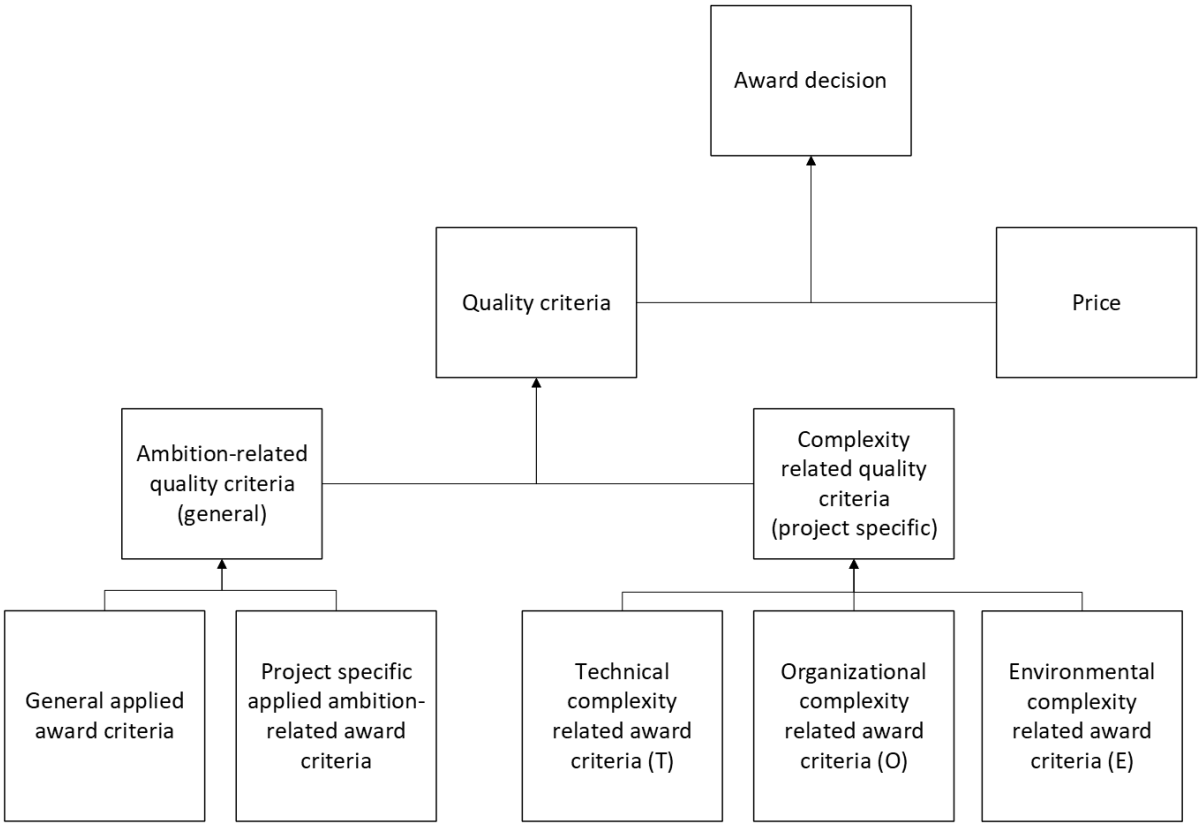

Figure 7: Award decision tree (own figure, Visio)

2.5 Award criteria

In the procurement of infrastructure projects, award criteria are applied as a mechanism to evaluate and select the most suitable bids for infrastructure projects (Pianoo, n.d.). However, the role of award criteria can be different for every stakeholder. The goal is not only to award contracts to the lowest bidder but to ensure that the selected contractor also aligns with other objectives. In this chapter, the role of award criteria and their subjective character are described.

2.5.1 The role of award criteria

For years, using award criteria in tendering has been a key way to boost competition in the market and improve the quality of projects. By encouraging this competition, contractors need to innovate in various areas to differentiate from others (Lenderink et al., 2020). Wargers (2021) defines the distinctive capability as the extent in which a bidder has the possibility to acquire work on non-price criteria in a public tender procedure. This distinctive capability is important for contractors in winning tenders, but also to decide whether to bid or not bid in a tender (Slockers, 2019). Describing the right award criteria for tenders is a challenging process for contracting authorities. There are many factors influencing this process, such as the ambitions of the client, which are constantly evolving. Therefore, the selection of the award criteria in infrastructure tenders is a continuously developing process.

In the past, tenders were mainly awarded on price, but the standard contracts lacked encouraging contractors to perform to the best of their ability (Vassallo, 2007). Nowadays, quality is evaluated through a wider range of criteria. Quality can be assessed in many different ways. Quality can be assessed via ambition-related award criteria, often based on an organizational policy. Quality can also be assessed through project-specific award criteria, that are related to specific project goals, such as minimizing risks or minimizing disruption. These award criteria are not applied for each tender and therefore are project specific.

Contracting authorities aim to score bids on quality to achieve a fictive reduction in the bid price (PianOo, n.d.). This requires a good balance between quality and price. A bid with high-quality scores should get enough notional discount on its price to make focusing on quality more worthwhile than just aiming for a low price (Dreschler, 2009). However, if the notional discount is minimal and it is difficult for contractors to distinguish themselves on quality, the tender effectively turns into a price-driven competition.

Therefore, choosing the right criteria and their proportionalities is an important steering mechanism. This task is crucial for contracting authorities to stimulate and guide the infrastructure market (Crucq & Bossink, 2011). However, public interests are changing and influencing the construction sector. Projects are becoming more complex, which requires new procurement approaches that use different award criteria to select the most suitable contractor. These award criteria could reflect public values that are constantly changing or reaching new standards. What used to be a highly sustainable approach is now developing towards a required minimum (Terlien, 2024). The market, particularly the contractors, must respond to the changing demands of the public clients in the Netherlands.

Award criteria are applied to create competitive differentiation among contractors and to highlight the key aspects of a project from the client's perspective (Bryde & Robinson, 2005). To understand the role of award criteria in the whole procurement process, it is crucial to distinguish between suitability requirements, selection criteria, and award criteria. Suitability requirements assess whether a bidder is qualified to participate in a tender, while award criteria assess the bid itself. A bidder must meet the suitability requirements to participate in the next phase of the tender process.

To ensure the efficient use of capacity of both client and contractor, it is not wise to have too many parties participating in the tender (Crucq & Bossink, 2011). Therefore, a selection phase could be included in the process to narrow down the pool of qualified candidates. The criteria in this phase are called selection criteria. And finally, award criteria are used to evaluate the bids of the participating contractors.

Table 1: Suitability requirements, selection criteria and award criteria (own figure, based on PianOo, n.d.)

Aspect	**Suitability requirements**	**Selection criteria**	**Award criteria**
Purpose	Assessing whether a bidder is qualified to participate	Reducing the number of qualified candidates	Evaluating which bid is the best
Moment of application	Before evaluating the actual bids	When there are more qualified candidates than the client wants to (market strategy)	During the evaluation of submitted bids
Outcome	"Qualified" or "Not Qualified"	A list of the best suitable candidates	A ranking of bids
Use	Granting access to the tendering phase	Selecting the most suitable candidates for the tender phase	Awarding the contract to the best bidder
Example	At least 3 years of experience in similar projects	Ranking based on the number of completed complex projects	Scoring on price and quality aspects such as sustainability or hinder

For a better understanding of the distinction between a selection criterion and an award criterion, the MoSCoW prioritization framework is used (Clegg, 1994). The MoSCoW method is a prioritization framework that categorizes requirements or criteria into four groups: Must-have, Should-have, Could-have, and Won’t-have.

"Must-have" represents essential elements that are critical to the success of a project. In the context of tenders, these correspond to the mandatory suitability requirements specified in the contract. "Should-have" includes the selection criteria, which are not strictly necessary, but which are important when ranking contractors. "Could-have" refers to desirable elements (i.e. "nice-to-have" elements) that add value but are not crucial. These are the award criteria. Scoring well on these criteria is not mandatory but increases the chances of winning the contract. Finally, "Won’t-have" identifies elements that are not within the project's scope. Implementing these aspects does not add value and only increases costs for the contractor.

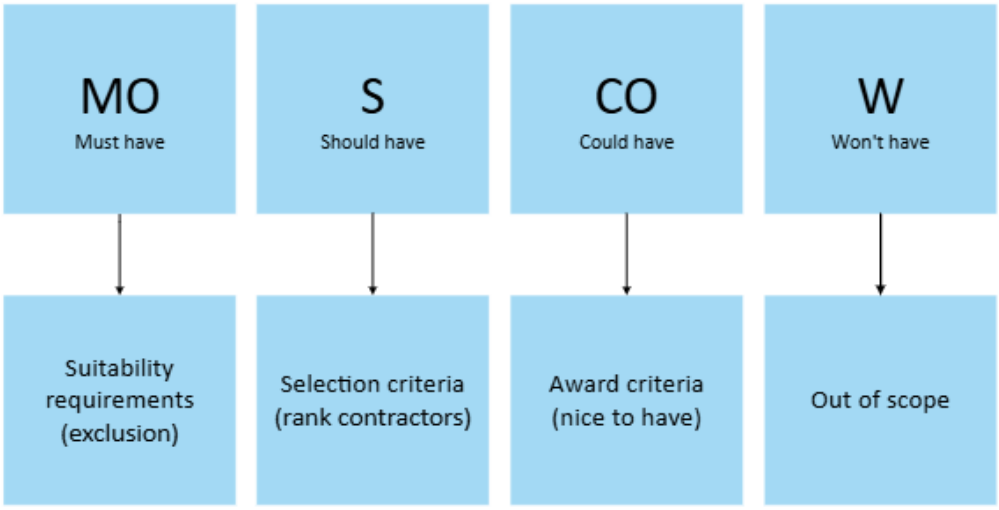

Figure 8: Moscow framework applied to tenders (own figure, based on Moscow framework (Clegg, 1994))

As shown in the figure above, award criteria are “nice-to-have” elements of a contractor’s project plan. These award criteria could help achieving certain project objectives. However, quantified objectives can be addressed in various ways; one objective might be framed as a requirement, while another might be presented as an award criterion (Schotanus & Siersema, 2023). Over the years, expectations around certain award criteria have grown, to the point where some award criteria have become requirements. Evolving standards not only drive innovation but also impact the competition between contractors when minimum requirements are raised (Schotanus & Siersema, 2023). Contracting authorities must carefully consider whether certain aspects should be included as minimum requirements in a tender or whether contractors should be given the flexibility to differentiate themselves. Increasing the number of requirements or increasing the minimal standards of requirements reduces the solution space for contractors, as shown in figure 10. This influences the distinctive capability for contractors. Setting high quality standards and thereby leaving little room for differentiation results in a price-driven competition, because contractors will no longer be able to differentiate themselves on quality aspects. The figure below illustrates what happens with the solution space for contractors when adding more requirements.

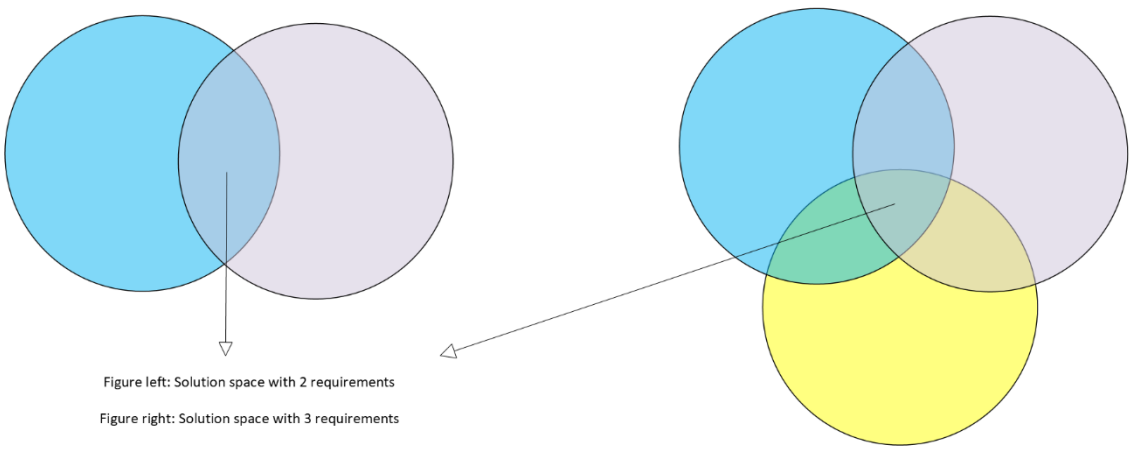

Figure 9: Solution space for contractors with 2 or 3 equal requirements (own figure, based on PianOo, n.d.)

2.5.2 Subjective character of award criteria

The primary function of contract award criteria, as emphasized in Recital 92 of the preamble to Directive 2014/24/EU, is to enable a comparative assessment of the level of performance offered in each tender for the subject of the contract (European Parliament and Council, 2024). This is the objective purpose of award criteria. However, in practice, the role of award criteria in public procurement can also be perceived as subjective.

One key function is to support the achievement of ambitions, particularly those related to policy goals such as social sustainability or environmental impact (Lingegard et al., 2021). In this way, award criteria serve as a mechanism for integrating societal objectives into procurement decisions. Grandia and Meehan (2017) mention that especially in the public sector, policies to encourage societal goals may influence criteria and strategies. Since these ambitions are organization-specific, the criteria tend to be subjective.

Another crucial role of award criteria is to maintain control over the project process and its outcomes. In that way, award criteria are applied to ensure that the contractor's bid aligns with project goals and possible risks. Which risks are identified for a project is also subjective. Burke & Demirag (2017) mention in their sample risk allocation matrix that multiple risks categories, for example planning risk and operational risk, could be transferred to the contractor. This can be achieved by addressing project-specific award criteria.

In a paper of Ng et al. (2002) it is mentioned that the selection of the procurement method is also considered as subjective. While some criteria, such as time- and price certainty are considered objective, others like quality level, risk allocation and flexibility are considered subjective. The perception of these criteria varies among public authorities. Because of these different perceptions, it is difficult to decide what is perceived as "good". Complexity is considered subjective as it is difficult to define universally and it depends on project familiarity and stakeholder experience (Ng et al., 2002). Besides the type of award criteria selected for a project, the weights and the evaluation of these criteria are also considered to be subjective.

Weights of award criteria

The weighting of award criteria plays a crucial role in shaping the role of those criteria. The weighting of award criteria is a powerful mechanism that helps contracting authorities to prioritize project objectives or organizational ambitions. Because the weighting can be interpreted as a prioritization of the award criteria, it can also be considered subjective. The information about the weights is essential for contractors to align their bidding strategies with the prioritization of the client. Higher weights represent higher fictive reductions in the bid price. The weighting of award criteria must be carried out with care. Inappropriate weighting would cause problems when carrying out the evaluation of tenders and could mean that the tender offering the best value for money would not be selected (Načisčionis & Skrastiņa, 2016).

In infrastructure projects, and particularly in R&R tenders, the challenges associated with integrated assets often lead to higher weights for technical expertise, risk mitigation, and lifecycle performance (Lenderink et al., 2020). Therefore, prioritizing these criteria in a bid increases the chances of securing the contract. Similarly, higher weights can be assigned to policy-driven priorities, such as environmental and social sustainability (Montalbán-Domingo et al., 2019). The weighting of award criteria ultimately depends on the strategic preferences of the contracting authority i.e. the subjective character of award criteria.

Evaluation of award criteria

While the weighting of award criteria is important for prioritizing project objectives, a high weight will only influence the tender outcome if contractors also have sufficient opportunity to differentiate themselves on that criterion (PianOo, n.d). The distinctive capability is influenced by the evaluation method. Particularly when both price and qualitative factors are considered, the choice of scoring methodology can influence how contractors position their proposals (Fazekas & Blum, 2021). The scoring methodology used can significantly impact a contractor's ability to differentiate itself. While a broader scoring scope creates more differentiation possibilities and incentivizes contractors to submit higher-quality proposals, it also increases the complexity of fair and transparent evaluation. The evaluation is intended to be objective, but there is always a degree of subjectivity in how bids are assessed, particularly when the boundaries between scoring levels are unclear or narrow. When projects involve high levels of uncertainty, technical complexity and evolving requirements, bid evaluation becomes more difficult (Baldi et al., 2016). For these projects, a combination of objective criteria (cost, technical specifications) and subjective criteria (collaboration, risk management) is preferred (Baldi et al., 2016).

Furthermore, the way an award criterion is formulated has a direct impact on how it's interpreted. Contractors may submit different proposals based on what they believe is the best response to the criterion. However, those proposals might not align with what the contracting authority actually had in mind. Grandia and Meehan (2017) mention that it is important to align the contractor proposals with client expectations to achieve organizational ambitions. As a result, a plan can receive a lower score simply because, in the eyes of the evaluators, it doesn't meet their expectations. This again highlights the subjective nature of award criteria.

2.6 Conceptual model

Overall, the selection of award criteria is influenced by both organizational ambitions and project objectives, which are shaped by complexity-related risks. This selection is a subjective process and may vary from one procurement procedure to another, as the criteria need to align with the specific objectives of each project. Figure 10 presents a conceptual model that illustrates the sources that influence the selection of award criteria. It is important to note that other factors may also play a role in this decision-making process, but these are not included in this conceptual model.

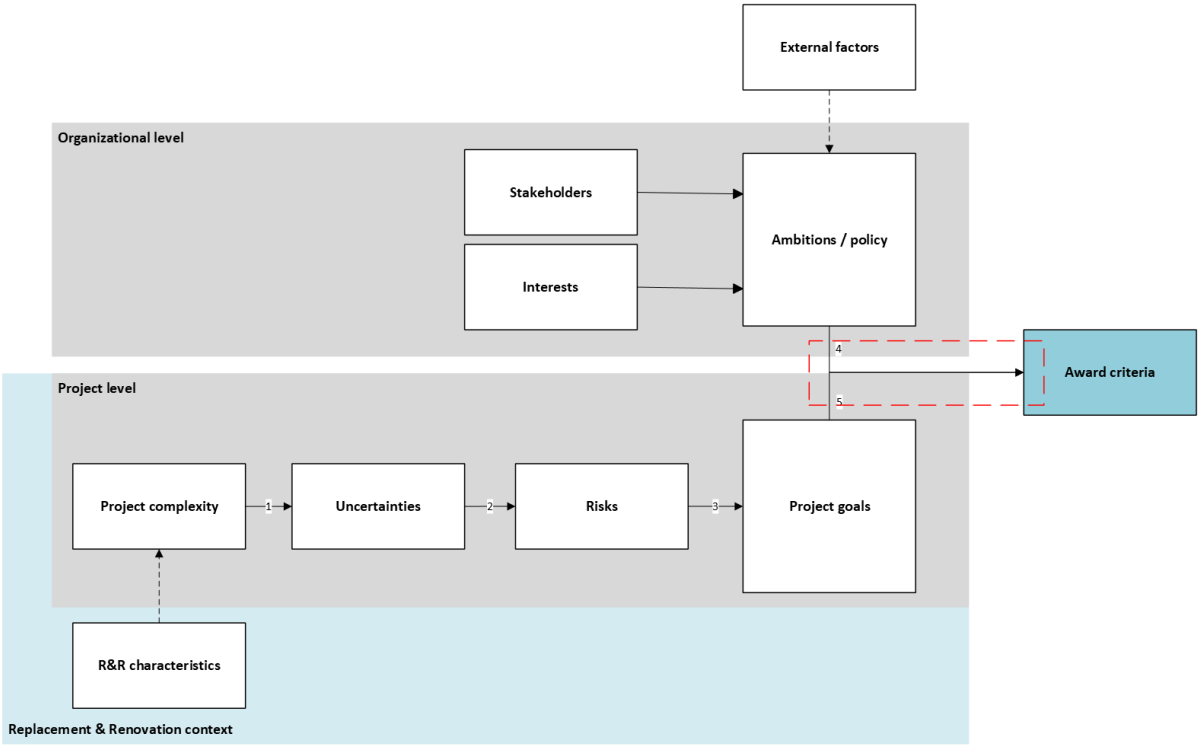

Figure 10: Conceptual model of award criteria selection (own figure, Visio)

The conceptual model will be used to analyze the basis on which award criteria are selected for ProRail's R&R projects. By applying this model, a distinction can be made between criteria that reflect organizational ambitions and criteria that reflect complexity-related risks. This helps in understanding the extent to which projects are awarded based on the ability of a contractor to minimize complexity-related risks. For R&R projects this could be important, as the success of a project is maybe more depending on a successful project delivery then achieving sustainability goals. Numbers 1 to 5 in the figure refer to sources that explain the relationships between the elements (boxes) shown.

1. Whitty & Maylor (2009): Complex projects involve non-linear components that introduce uncertainty.
2. Perminova et al. (2008): Uncertainty is defined as "a context for risks as events having a negative impact on the project's outcomes, or opportunities as events that have beneficial impact on project performance".
2. Vidal and Marle (2008): Uncertainty appears as one of the possibly negative consequences of project complexity.
3. Jaafari (2001): With increasingly complex projects, risk management becomes more important and risk management should be done throughout the whole life cycle of a project.

4. Lingegard et al. (2021): One key function is to support the achievement of ambitions, particularly those related to policy goals such as social sustainability, environmental impact, or innovation.
4. Grandia and Meehan (2017): Especially in the public sector, policies to encourage societal goals such as social sustainability or innovation may influence criteria and strategies.
5. Schieg (2006): Risk control consists of four methods to control the risk, which are avoidance, reduction, passing on the risk and bearing the risk by oneself.
5. Burke & Demirag (2017): Multiple risks categories, for example planning risk and operational risk, could be transferred to the contractor.

3. Case study setup

This chapter outlines the case study setup, including the data collection, data analysis and data validation. Also, the justification of the research methodology is described and wrapping up this chapter with the research standards according to Bryman (2008).

As presented in the thesis outline, this study consists of three parts: literature (1), case studies (2) and discussion and conclusion (3). During the case studies, 4 projects of ProRail were analyzed. The discussion reflects on the findings of the case studies and the literature. In the conclusion chapter, answers to the main- & sub-research questions are formulated.

The answers on sub-questions 1, 2 and 3 can be formulated by conducting a literature study. The answers on sub-questions 4, 5, 6 and 7 can be formulated by conducting document analyses and semi-structured interviews within the case studies. Finally, the answer on the main research question can be formulated by merging answers on the sub-questions. The conceptual model, which summarizes the literature research, is the starting point for the case studies. The following sections describe these case studies in detail.

3.1 Case study selection

This chapter describes the selection of ProRail as the public authority that is analyzed in this research, as well as the criteria used to select the case studies. Each case study focuses on a tender of a ProRail project that fits within the definition of Replacement & Renovation and includes MEAT criteria in the procurement process.

Selection of ProRail

In the report by Rasker et al. (2023), a forecast is presented concerning the replacement and renovation of civil infrastructure in the Netherlands. According to this forecast, 23% of the total estimated costs are allocated to the national infrastructure managers Rijkswaterstaat and ProRail. Although the exact distribution between these two organizations is not specified, this percentage underlines the relevance of taking a closer look at the replacement and renovation task facing ProRail.

As the manager of the Dutch railway network, ProRail is responsible for the maintenance and renewal of the Dutch railway infrastructure. They constantly carry out replacement and renovation (R&R) projects to ensure the safety and reliability of the rail system. In 2024, more than 400 railway projects were planned, which is a record number that highlights ProRail's important role in the R&R challenge in the Netherlands (Prorail, 2024).

In addition, ProRail is actively working to innovate its procurement processes. The organization desires greater flexibility in procurement to enable more efficient maintenance carried out by contractors (SpoorPro, 2024). This focus makes ProRail a relevant organization for exploring how award criteria are applied in practice for their R&R projects.

Selection of projects (cases)

For the selection of ProRail projects, the tender database of BAM Infra was used as the primary source. This database contains records of projects for which BAM Infra submitted tenders, including a large number of ProRail projects. To narrow down the selection, discussions were held with a tender manager from BAM Infra to identify projects that are both relevant and aligned with the definition of an R&R project, as described in the literature research.

To ensure a meaningful comparison and avoid selecting entirely different types of projects, four projects were chosen in which MEAT criteria were applied to compare the bids. Each

project includes criteria based on the ambition of ProRail as well as criteria derived from the project's complexity. This was a mandatory requirement.

In total, four projects were selected. Project 1 and 2 are both projects that are part of a larger program. More of these projects will be tendered in the coming years. Therefore it is interesting to zoom in on these projects. Project 3 and 4 are standalone R&R projects, but are integrated into crowded areas. Therefore complexity within these projects was expected. The table below provides an overview of the four selected projects, including the contract type, the applied award criteria and a brief explanation of each project.

Table 2: Project overview

Project	Contract type	Applied award criteria	Project explanation
P1: GP BVL	UAV-gc	4 ambition criteria 2 complexity criteria	Part of a large-scale ProRail program to renew and renovate overhead lines reaching the end of their lifespan. This nationwide project focuses on sustainable renovation where possible, minimizing environmental impact. The challenge for projects within this program is to improve the project execution to deliver these projects more efficient.
P2: ERTMS	UAV-gc	2 ambition criteria 3 complexity criteria	Part of the European Rail Traffic Management System (ERTMS) program, this project enhances railway safety. It serves as a benchmark for future system upgrades, replacing outdated safety systems that no longer meet safety standards.
P3: IJ-viaduct	UAV-gc	2 ambition criteria 2 complexity criteria	This project involves the renovation of the IJ-Viaduct, addressing material fatigue and ensuring safety. The project must minimize disruptions to ongoing railway operations, making it a complex case for R&R research.
P4: GOS	Two-phase (Bouwteam)	1 ambition criteria 5 complexity criteria	This project ensures the long-term functionality of railway infrastructure at Schiphol Airport. Due to high passenger volumes and stakeholder interests, it is a complex project requiring minimal service disruptions.

The underlying figure shows how the four selected R&R projects are located within the Kraljic Matrix (1983). The positioning is based on their strategic importance and market risk. This could help justify the procurement approach for each project.

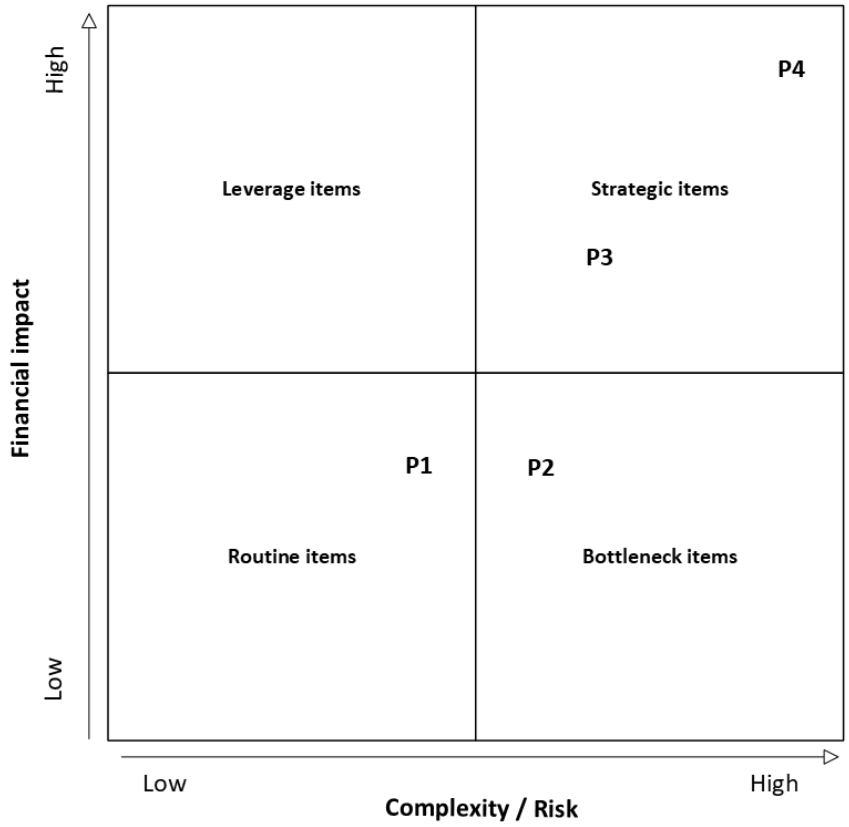

Figure 11: Kraljic matrix (1983) with positioning of four projects (own figure, Visio)

P1 – GP portals (Routine)
P1 is positioned in the routine quadrant. This indicates a low level of complexity and limited financial impact. This type of project could be standardized and the complexity lies especially in the improvement of project execution efficiency. The main objective here is efficiency, and innovation should be focused on improving the execution methods to maximize output within limited market capacity. According to the Kraljic matrix, the procurement approach should focus on price and standardization. This is not in line with the weighting of quality criteria, but when including the distinctive capability for contractors on the quality criteria, it is in line with the focus on price and standardization.

P2 – ERTMS (Bottleneck)
P2 is positioned in the bottleneck quadrant. Although this project is part of a program and could be seen as routine work, currently there is still a lot of uncertainty about the implementation of this new safety system, i.e. complexity due to the little experience of both contractors and client. The ERTMS project involves new technologies and interfaces with existing systems, which makes market expertise crucial. Because the market is limited, and execution comes with risks, the procurement should emphasize these challenges. Therefore, the use of quality criteria is preferred over price competition. When more knowledge is obtained about the implementation of ERTMS, this type of project could make a shift towards the routine projects, with a focus more on price rather than on quality.

P3 – IJ-Viaduct (Strategic)
P3 is positioned in the strategic quadrant, which means that this project has a high financial impact on ProRail's organization and also a high level of complexity. This kind of project requires close collaboration between the client and the contractor and a quality-driven

procurement strategy is preferred. Award criteria here should reflect the contractor's ability to manage complexity, minimize disruption, and deliver the project under challenging conditions.

P4 – GOS (Strategic)
P4 is also positioned in the strategic quadrant, but even further to the top right corner than P3. This is in line with the technical, organizational, and external challenges, for what early contractor involvement and flexible cooperation is desirable. ProRail appropriately used a two-phase contract for this project, and the award strategy should prioritize collaborative capability, adaptive planning, and stakeholder engagement.

As mentioned in the theoretical framework, the contract type of a project could influence the selection of award criteria. The award criteria, which are used to express quality, could be different for traditional UAV-gc contracts then for the procurement of a two-phase contract. These two-phase contracts focus more on the collaboration between client and contractor. Therefore, it was reasonable to also focus on a two-phase “construction team contract” contract. By adding this type of contract in the analysis, the understanding of the translation of complexity into award criteria will be improved. According to the Kraljic matrix (1983) a strategic project should focus more on collaboration and quality then solely on price. Including a construction team contract as case helped in understanding if ProRail aligns their procurement approach with the complexity of the project.

3.2 Data collection

The data collection for the case studies consists of three components. These components strengthen triangulation and are needed to improve the understanding of how award criteria are used in R&R projects.

1. Policy documents. As visualized in the conceptual model, award criteria can be ambition-driven. Therefore, gathering information about the policy and ambitions of ProRail is important to understand the selection of award criteria. Two documents were selected for the analysis: *Masterplan 2026–2030* (ProRail, 2024) and the *Asset Management Plan 2024–2025 (Beheerplan 2024-2025)* (ProRail, 2023).
2. Tender documents. Multiple tender documents are collected to create an overview of the used award criteria and their weightings.
3. Semi-structured interviews. Interviews are conducted with ProRail project managers and tender managers to understand how project complexity is perceived and what the reasoning is behind the selection and weighting of award criteria. Additionally, for each case an interview with a contractor was conducted to gather knowledge about the perspective of the contractor on the project complexity and distinctive capability of the selected award criteria. Because the semi-structured interviews are a major part of the data collection, a separate section will elaborate more on these interviews.

3.2.1 Semi-structured interviews

For each project, two semi-structured interviews were conducted at ProRail to assess how the topics from the theoretical framework are reflected in practice. One interview was conducted with the project manager, focusing on the specific challenges of the project and how these were addressed. The second interview was conducted with the tender manager, who joins the project when preparations for procurement begin. Depending on the project's complexity, this person may be involved earlier in the process. This interview focused on the award criteria that were selected and the reasoning behind their use, but also complexity related questions were asked.

Aspects mentioned during the interviews were linked to elements of the TOE framework to improve the understanding of what type of complexity was mentioned by the participants. Subjectivity plays a role when applying this framework as a complexity identification tool. However, when using the framework as identification tool, the knowledge of a project manager and tender manager can be considered a validated source of information regarding the complexity that was identified before tendering the project.

By combining the knowledge of both experts, sufficient input was gathered to understand how ProRail's project and tender managers perceive complexity in the selected R&R projects and what role award criteria play in managing this complexity. In addition to the eight interviews at ProRail, interviews were conducted with the tender managers of the contractors involved in each case to gather insights into the contractor's perspective on the selected award criteria and distinctive capabilities. In appendix A, the interview setups are presented.

3.3 Data analysis

The data analysis consists of two parts: a document analysis and an interview analysis. The document analysis consists of two parts and is carried out before the interviews were conducted. Insights in the tender documents contributed to the formulation of project-specific questions and created an overview of the selected award criteria for each project. The data analysis is visualized in the following figure.

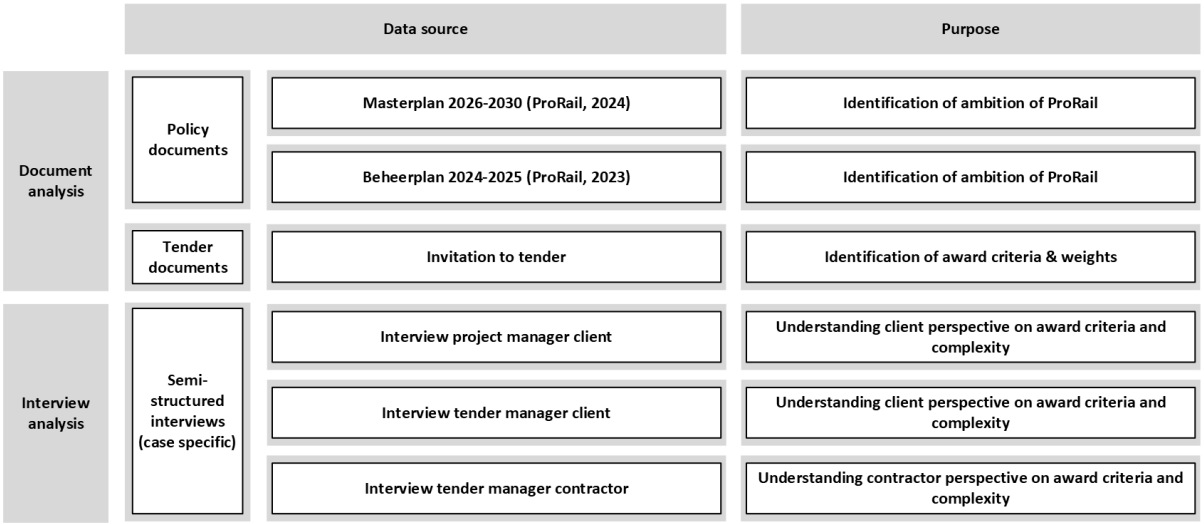

Figure 12: Overview data analysis (own figure, Visio)

Document analysis

The document analysis consists of two parts: an analysis of policy documents and the identification of award criteria and weights in the tender documents. The policy document

analysis was carried out once, as the policy of ProRail applies to all four projects. The analysis of tender documents, on the other hand, was conducted separately for each project. However, the explanation of this analysis is described only once, as the same step-by-step method was applied to all projects.

Policy documents

Analyzing ProRail's policy documents provides insight into the ambitions and strategic objectives that may influence the award criteria used in project procurement. The two selected policy documents were reviewed with a focus on identifying statements related to ProRail's ambitions. A summary table was created to present the identified ambitions, the corresponding information sources, and a brief explanation. This overview is included in Appendix F. These identified ambitions help to link award criteria to the organizational ambitions of ProRail.

Identification of award criteria and weights

The "invitation to tender" document is used to identify the award criteria and corresponding weights for each case. The ambition overview table helped assessing for each award criterion whether it is linked to an organizational ambition or to a form of project-specific complexity. The weightings of the criteria were included as well, since they reflect the emphasis placed by the client on each criterion. These weightings provide insight into which criteria the client considers most important for project success. However, this only reflects the client's perspective and does not necessarily indicate the contractor's ability to differentiate on that criterion. The potential for differentiation depends on the extent of flexibility offered to the contractor, the evaluation method used, and the level of competition in the market. The semi-structured interviews with the contractors are used to gather insights on these aspects.

Interview analysis

The interviews were analyzed using thematic coding, combining both deductive and inductive approaches. Initial codes were derived from the theoretical framework, while additional codes were added during the analysis to capture recurring answers and subthemes in the responses. Coding was conducted in Atlas.ti using summarized transcripts in a structured question–answer format, with irrelevant content excluded for clarity and efficiency.

These summaries made it easier to identify themes and link quotes to specific topics. This process improved the understanding of ProRail's use of award criteria and perceptions of project complexity. Project-specific questions provided insights into case-specific trade-offs, while general questions revealed recurring patterns. Data saturation was reached for some questions when no new insights emerged after several interviews.

Following Eisenhardt (1989), cross-case comparison could be used to identify underlying factors influencing decisions across projects. The cross-case analysis contributed to understanding the use of award criteria and the level of complexity for each project, because not every project was considered complex in the same way and also the award criteria were different for every project.

3.3 Data validation

The data validation is done through member validation and a validation interview with a tender manager of ProRail. The key takeaways from the interviews that were used in the results were sent to the participants for validation. This process minimizes the risk of misinterpreting information and is referred to as "member validation" (Bryman, 2012). After incorporating feedback from the interviewees, the accuracy of the transcripted interview data is improved.

To validate the findings and insights of this research, a validation interview was conducted with a tender manager of ProRail, who has many years of experience as a tender manager within ProRail. This interview was conducted as a validation step to test the generalizability of the earlier research findings, but also to check whether the conclusions were understandable. The respondent confirmed that both the complexity as the use of award criteria are project-specific. It was asked, whether the award criteria are representative for the award criteria that are used for R&R projects that include MEAT criteria. The validation is further elaborated in the discussion chapter.

3.4 Research standards

In the book *Social Research Methods* (Bryman, 2008), research standards for qualitative and quantitative studies are described. These standards guide the research process but are also influenced by the specific context of the study. For this research, the standards for reliability, validity, generalizability, objectivity, and replicability are discussed.

Reliability

The reliability of the research and its data is crucial. To ensure reliability, the semi-structured interviews were transcribed to document the questions and answers in detail. These transcripts were then shared with the participants to ask for feedback. Additionally, the key takeaways from the interviews that were used in the results were also sent to the participants for validation. This process minimizes the risk of misinterpreting information and is referred to as "member validation" (Bryman, 2012). After incorporating feedback from the interviewees, the accuracy of the transcripted interview data is improved.

Validity

In the fourth edition of *Social Research Methods* (Bryman, 2012), mixed methods are discussed as a way to enhance validity, especially in qualitative social research. Mixed methods combine quantitative and qualitative approaches within a single study. One of the key reasons for using mixed methods is to increase validity through triangulation. Triangulation involves using multiple methods, data sources, or perspectives to address a research question (Bryman, 2012).

In this research, data from tender documents is used to gather knowledge about the complexity of the project and information about the award criteria that are used for the procurement of the projects. Also policy documents are analyzed to gather knowledge about the ambition of ProRail. Furthermore, the complex aspects of the project are gathered via the document analysis as well as the semi-structured interview. During the interviews, the link has been made between the complex aspects of the project and the selected award criteria. By integrating these methods, triangulation strengthens both the validity and reliability of the results.

Generalizability

Bryman (2008) highlights that a research should aim for transferability, which is often referred to as generalizability. Generalizability in a case study research can be difficult, because case

studies focus on an in-depth analysis of a topic, which makes it difficult to extrapolate findings to larger populations. However, insights from case studies can still be valuable and applicable in other contexts.

In this research, the link between complexity of R&R projects and the use of award criteria is expected to provide useful insights for other clients as well as contractors. Further research could dive deeper into the use of award criteria of other organizations.

Objectivity

To ensure objectivity, several steps were taken during the research process. First, key concepts were defined using existing literature, so that interpretations were not based on assumptions. Second, a semi-structured interview format was used to create consistency across the interviews. Although there was flexibility to explore additional topics during the interviews, the format helped to keep the same interview set up. Finally, the interviews were analyzed in a structured way by using themes in Atlas.ti. However, objectivity is difficult to ensure in qualitative research, including semi-structured interviews and participant perceptions, but information bias is minimized by triangulation. The research validation was part of this triangulation.

Replicability

Bryman (2008) emphasizes that scientific research should be replicable by other researchers. This study can be replicated by first reviewing the literature and understanding the scope and definitions used. With that foundation, the methodology can be applied to other public clients.

Policy documents from public clients are often publicly available, but tender documents may not always be accessible. The tender information that is used for this research, is not publicly published. Therefore, access to these documents is needed to replicate the research. This depends on whether the client publishes their tender guidelines publicly or not. Therefore, replication is feasible for clients who make their procurement documents publicly available.

4. Findings

The results section presents the findings from both the document analysis and the interview analysis. The document analysis provides an overview of the applied award criteria and their respective weightings. The interview analysis focuses on qualitative insights, structured around key themes that correspond to the sub-questions of this research. For each theme, the relevant Atlas.ti codes are listed to indicate how the coded data contributed to the results in that section. Figure 15 presents the link between the sub-questions and the sections in this chapter.

Sub question	Section
SQ4	Award criteria and weights
SQ5	Client perspective on project complexity
SQ6	Contractor's perspective on project complexity
SQ7	Award criteria selection

Figure 13: Link between sub-questions and result sections

4.1 Award criteria and weights

In this section, the award criteria and the price-quality ratio are presented. Also, a distinction is made between ambition-related award criteria and complexity-related award criteria. The complexity-related award criteria are tailored to the specific project, where ambition-related award criteria are award criteria that are applied for almost all the R&R projects of ProRail. The first table presents the weighting of price and quality and the second table presents the distinction between the two types of award criteria.

Furthermore, the CO2 performance and Safety Culture Ladder criteria are a large part of the total weight of the quality award criteria (ambition-related). However, in the interviews it was mentioned that there is almost no distinctive capability for contractors on these criteria. Therefore, a column is added on the right to show more reliable percentages of the award criteria. The weighting of the price combined with the weighting of the quality adds up to 100%.

Table 2: Weightings price and quality

P1	Contract winner	Best score quality	No CO2 and SCL
Weighting price	31,35%	21,11%	41,11%
Weighting quality	68,65%	78,89%	58,89%
P2	Contract winner	Best score quality	No CO2 and SCL
Weighting price	58%	50%	70%
Weighting quality	42%	50%	30%
P3	Contract winner	Best score quality	No CO2 and SCL
Weighting price	64,20%	48,64%	58,64%
Weighting quality	35,80%	51,36%	41,36%
P4	Contract winner	Best score quality	No CO2 and SCL
Weighting price	-	10%	20%
Weighting quality	-	90%	80%

Also, a table is created that shows which part of the award criteria is derived from the ambition of ProRail and which part of the award criteria is derived from the project specific complexity. Also, for this table the CO2 performance and Safety Culture Ladder criteria are removed to present more reliable percentages. When removing the CO2 and SCL, the ambition-related award criteria are only the MKI and Zero Emission criteria. The complexity-driven criteria are the MEAT criteria that are tailored to specific project goals.

Table 3: Part of the quality criteria that is ambition-driven or complexity-driven

P1	With CO2 and SCL	Without CO2 and SCL
Part ambition-driven criteria of quality criteria	65,62%	54%
Part complexity-driven criteria of quality criteria	34,38%	46%
P2	With CO2 and SCL	Without CO2 and SCL
Part ambition-driven criteria of quality criteria	40%	0%
Part complexity-driven criteria of quality criteria	60%	100%
P3	With CO2 and SCL	Without CO2 and SCL
Part ambition-driven criteria of quality criteria	22,10%	3%

Part complexity-driven criteria of quality criteria	77,90%	97%
P4	With CO2 and SCL	Without CO2 and SCL
Part ambition-driven criteria of quality criteria	9%	0%
Part complexity-driven criteria of quality criteria	91%	100%

The results show that project 1 placed a strong emphasis on ambition-related criteria, with less focus on specific complexity-related criteria. In contrast, project 2 was fully focused on complexity, and project 3 also placed nearly all emphasis on complexity-related criteria. In project 2, the ambition-driven criteria consisted entirely of the CO_2 Performance Ladder and the Safety Culture Ladder (SCL), and in project 3, aside from a small MKI component, this was also the case. In project 4, the emphasis was placed for 80% on complexity-related award criteria. The other 20% is focusing on sustainability, but for during the interviews it was mentioned that for this project sustainability is interpreted as a project goal instead of an organizational goal (ambition). This award criterion focuses on minimizing future maintenance. Therefore, this 20% could also be interpreted as a complexity-driven award criterion. In that case, without CO2 and SCL, 100% of the quality criteria is complexity-driven for project 4.

Combining the weight of quality-driven criteria and the percentage of quality that is complexity related, results in the following table. The results in this table show the real weights of complexity-driven criteria in the four projects. These percentages include no information on the distinctive capability of contractors.

Table 4: Real weights of complexity-driven criteria

Project	**Weight of complexity-driven criteria**
P1	**27%**
P2	**30%**
P3	**40%**
P4	**80%**

Table 3 shows the actual weightings of complexity-driven award criteria across the three case studies. When these standard policy criteria are excluded, the share of criteria related to project complexity ranges from 27% to 80%. To answer the research question, information must be collected on the complexity of the four projects. Only then can it be determined whether there is a relationship between these percentages and the project's level of complexity. First, the following sections describe what the ambition-driven and complexity-driven award criteria are. These criteria are not presented separately for each project, but are instead discussed per type.

Ambition-driven award criteria

In addition to complexity-related criteria, ProRail tenders include ambition-driven award criteria that reflect broader organizational goals, particularly in the areas of sustainability and safety. For these projects, the ambition-driven award criteria are:

- CO_2 Performance Ladder
- Safety Culture Ladder (SCL)
- Environmental Cost Indicator (MKI)
- Zero Emission

The CO_2 Performance Ladder and SCL are standard policy-based criteria applied across almost all tenders and are not tailored to the specific project context. Both ProRail and contractor interviewees noted that these criteria offer little to no room for contractors to distinguish themselves. According to ProRail, this is not necessarily problematic, as most contractors already meet the highest certification levels, which is positive. However, these criteria cannot be used to compare bids and select the best suitable bid for the project.

In contrast, MKI (Environmental Cost Indicator) and Zero Emission are directly tied to the execution phase and are influenced by specific project conditions. Their applicability and impact depend on factors such as technical constraints, phasing requirements, and site accessibility. These factors are common sources of project-level complexity, causing MKI and Zero Emission to partially overlap with complexity-related considerations. For example, new zero emission equipment requires different logistical planning, because their operating range differs from traditional equipment, due to their limited battery capacity.

Complexity-driven award criteria

In addition to ambition-driven criteria, several award criteria were identified that specifically relate to the complexity of the project. These complexity-driven criteria are tailored to the unique risks of each R&R project. Therefore, these are the MEAT (Most Economically Advantageous Tender) criteria. These award criteria aim to assess how contractors can anticipate and manage these risks. The following list provides an overview of the complexity-related award criteria found in the analyzed tenders:

- *Risk of capacity shortages*. Evaluation of the contractor's ability to prevent and manage complications caused by shortages in material, equipment, or personnel. This is particularly relevant in the current market with little resource availability.
- *Disruption mitigation (for railway operators)*. Measures proposed to minimize operational disruption for railway operators, such as NS and freight carriers. To monitor the effect of track possessions on network availability, a key performance indicator (KPI) was developed in collaboration with passenger operators (NS and Arriva) and freight operators. This KPI is expressed through ERM (Extra Experienced Passenger Minutes) and EGU (Extra Freight Hours) (ProRail, 2024). These KPI's are linked to the operational free periods (TVP) that are needed for the execution of a project. Not completing the project within a TVP results in extra ERM and EGU.
- *Disruption mitigation (for environment)*. Plans aimed at limiting nuisance for local stakeholders, including residents, businesses, and public space users. The two disruption criteria could also be included into one risk dossier, in which both disruption for operators as for the environment is included.
- *Disruption impact score*. A quantitative indicator (e.g., point system or fictitious discount) used to objectively compare the level of disruption reduction proposed in different bids. The disruption score depends on for example the timing and duration of planned operational free periods (TVP).

- *Robustness of the project plan*. Evaluation of the contractor's ability to manage and control risks related to project delays or timeline overruns.
- *Collaboration.* Assessment of the contractor's capacity to work effectively with the client and other parties, including subcontractors and suppliers.
- *Sustainability as a project objective*. Focuses on design and execution choices that improve long-term maintainability and reduce future operational effort. This criterion seems to be an ambition-driven criteria. However, in the interviews with ProRail it was mentioned that this criterion focuses on reducing future disruption and therefore can be interpreted as a project-specific objective that is related to complexity.

The analyzed award criteria show that several complexity-related elements are considered in the tendering process. During the interviews, collaboration was frequently mentioned as a crucial factor, especially in projects with a high level of uncertainty. Multiple respondents mentioned that effective collaboration between client and contractor is essential for anticipating and addressing challenges that cannot be fully specified in the requirements in advance. Collaboration, however, is a vague concept and can be interpreted in many ways. For that reason, the next section will explore in more detail what is meant by collaboration as an award criterion.

Collaboration as award criterion

In P3, collaboration is assessed through a plan in which the contractor must elaborate how they intend to collaborate with all parties involved in the project. The criterion consists of two components:

1. *Working together*. This focuses on the contractor's approach and attitude towards collaboration with the client, other contractors, and stakeholders. This part describes how the contractor envisions stakeholder engagement throughout the project.
2. *Organization*. This focuses on how the contractor's internal team structure is designed to facilitate effective collaboration. This includes the deployment and responsibilities of key personnel, and how continuity and quality are safeguarded when there are team changes. It addresses a wide range of topics, such as design, disruption mitigation, planning, phasing, interfaces, risk management, and coordination of track possession frameworks (TVP). In this sense, the criterion can almost be interpreted as an assessment of how responsibilities are organized to address the project's complex challenges.

Thus, "collaboration" in this context refers to more than just effective communication. It includes the contractor's ability to deal with a wide range of topics. In an interview with a tender manager it was mentioned that this collaboration criteria can be interpreted the same as the way a contractor deals with possible risks. It just depends how a criterion is formulated.

In P4, collaboration is assessed through a team assessment conducted during the dialogue phase. Individual team members are evaluated, and their scores are combined to generate an overall score for the entire project team. This score translates into a fictive discount in the tender evaluation. This method has a subjective character. It places strong emphasis on the fit between the client and the contractor's team and could also be highly influenced by one individual.

In P2, collaboration is assessed through a written plan that describes how the contractor intends to mitigate the risks of insufficient collaboration with engineers, subcontractors, and suppliers. The plan must outline, in a SMART (Specific, Measurable, Achievable, Realistic, and Time-bound) way, how these risks will be addressed during project execution.

Overall, collaboration is assessed in different ways in three of the four projects. The results show that the criterion "collaboration" fulfills multiple functions. This highlights the importance

of well understanding the criterion collaboration and especially the way it is assessed. The results present no information if the selected assessment method reflects a good collaboration during project execution.

Shared focus in award criteria: Minimizing disruption

Although the complexity-driven award criteria cover different topics, they all seem to focus on the same underlying goal: minimizing disruption. This can be linked to several aspects:

- Disruption for railway operators, by completing the work within the operational windows (TVPs). This is monitored through ERM and EGU scores (KPI).
- Disruption for the surrounding environment, by limiting nuisance for residents, businesses and other local stakeholders.
- Avoiding future disruption, through sustainable design choices that make future maintenance easier or less frequent.
- Avoiding delays, by assessing the robustness of the project plan and the contractor's ability to avoid capacity issues (across projects).
- Avoiding coordination issues, by focusing on collaboration between client, subcontractors and suppliers.

Although these criteria are formulated and assessed differently, all MEAT criteria ultimately contribute to the same objective: minimizing disruption for operators, the environment, and future operations.

Visualization of award criteria

In the underlying figure, the identified award criteria are integrated in the award decision tree (figure 8) from the literature research. This shows which award criteria are connected to which type of complexity.

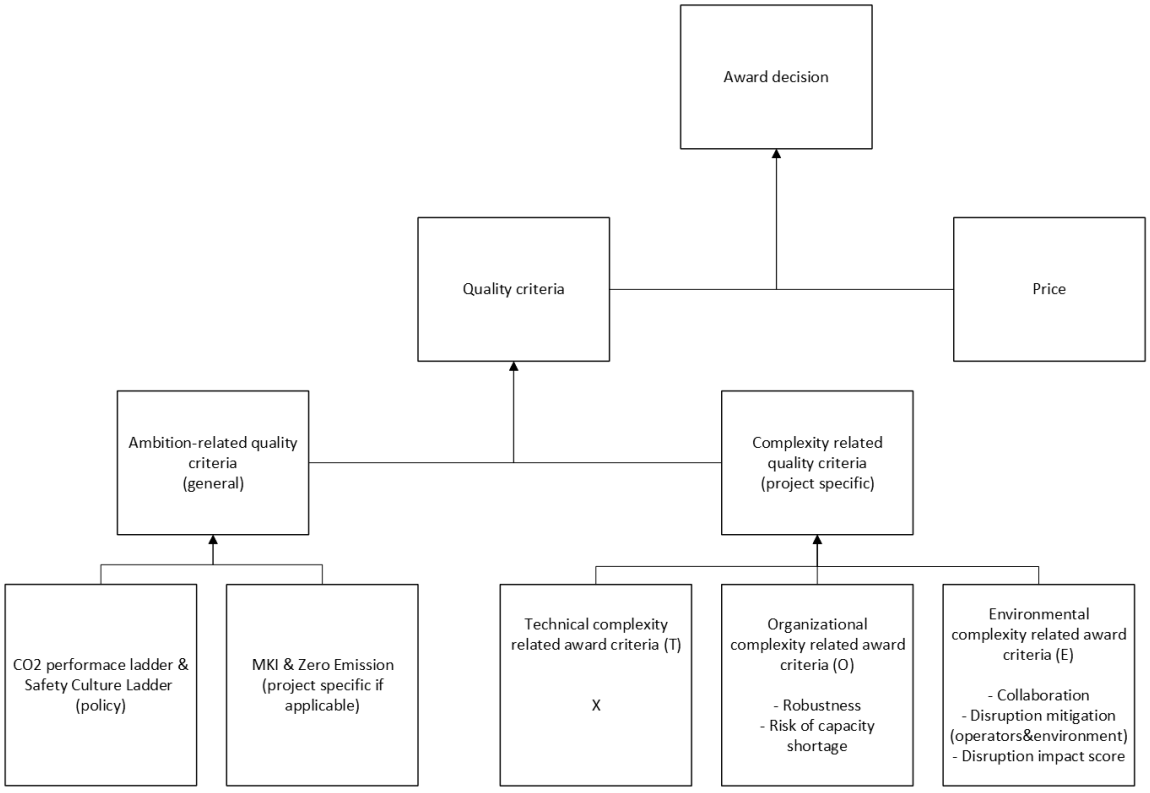

Figure 14: Award decision tree including award criteria (own figure, Visio)

4.2 Interview analysis results

This chapter presents the results of the qualitative analysis based on the semi-structured interviews conducted with ProRail project and tender managers, as well as with contractor tender managers involved in the selected R&R projects. The findings are structured around three main themes, each reflecting a different part of the research:

- Client perspective on project complexity
- Contractor perspective of project complexity and distinctive capability of award criteria
- Considerations in award criteria selection

This information is important to describe the complexity of the projects and link this to the insights of the document analysis. This helps in analyzing whether complexity-driven award criteria are used more frequently for complex projects compared to less-complex projects.

4.2.1 Client perspective on project complexity

As described in the literature, assessing project complexity is a subjective process. Perceptions of complexity will therefore differ from person to person. Although the contracting plan and the associated risk allocation are developed jointly with the project team, the project manager often has a different view of a project's complexity than the tender manager. To gain a well-rounded understanding of the complexity in each project, both experts were asked what made the project complex. The complex aspects that are mentioned in the semi-structured interviews at ProRail are divided into the three categories of the TOE-framework (Bosch-Rekveldt et al., 2011). Table 4 presents the mentioned elements for each project.

Table 5: Complexity elements mentioned in each project

Technical complexity elements	**P1**	**P2**	**P3**	**P4**
Uncertainties in scope (TS2)			**X**	**X**
Quality requirements (TS3)	**X**	**X**		
Dependencies between tasks (TT2)	**X**		**X**	**X**
Newness of technology (TE1)		**X**		
Experience with technology (TE2)	**X**	**X**		
Organizational complexity elements	**P1**	**P2**	**P3**	**P4**
Project duration (OS1)	**X**	**X**	**X**	**X**
Project drive (ORE1)			**X**	**X**
Resource and skills availability (ORE2)	**X**	**X**		
HSSE awareness (ORE4)		**X**		**X**
Interfaces between different disciplines (ORE5)	**X**	**X**	**X**	
Environmental complexity elements	**P1**	**P2**	**P3**	**P4**
Number of stakeholders (ES1)		**X**	**X**	**X**
Variety of stakeholders' perspectives (ES2)			**X**	**X**
Political influence (ES4)		**X**		
Interference with existing site (EL1)	**X**	**X**	**X**	**X**

Project complexity

Table 4 provides an overview of the complexity elements identified in each project, structured according to the TOE framework (Technical, Organizational, Environmental). The presence of each element is based on insights gathered from the interviews with project and tender managers.

In terms of technical complexity, *uncertainties in scope (TS2)* were particularly present in P3 (IJ-Viaduct) and P4 (Schiphol tunnel), where a significant portion of the work could not be defined at the time of tendering. P2 (ERTMS) was characterized by the introduction of a new signaling system. Thus, both the elements *newness of technology (TE1)* and a lack of *experience with the technology (TE2)* were mentioned. *Dependencies between tasks (TT2)* were mentioned in three of the four projects, especially in P1 (GP BVL), where the planning of work packages over a long project duration required careful phasing due to limited capacity.

Organizational complexity appeared in all four projects. *Resource and skills availability (ORE2*) was a recurring concern due to labor market shortages and the specificity of the technical work. *Project drive (ORE1*), reflects the internal motivation and coordination effort, which was explicitly mentioned in P3 and P4, where collaboration and planning were seen as key to success. The ERTMS and GOS projects also required specialized safety measures, which aligns with the *HSSE awareness (ORE4)* element. The element *Project duration (OS1)* is mentioned for every project, but in different ways. It is not the length of the project itself that contributes to complexity, but how time affects uncertainty. In P1 (GP BVL) and P2 (ERTMS), the long duration of the project (TVP's divided over multiple years) created uncertainty over time. Interviewees noted that it was difficult to maintain planning certainty, availability of key resources, and technological relevance across several years. In contrast, P3 (IJ-Viaduct) and P4 (Schiphol Tunnel) were characterized by very short execution windows, which introduced pressure and reduced flexibility. Project managers emphasized the risks of tight schedules, especially in combination with high stakeholder expectations and operational restrictions.

Finally, environmental complexity was highly relevant in all projects. *Interference with the existing site (EL1)* occurred in all four, as each project had to be executed while rail operations continued and the infrastructure was already integrated in its environment, which is logical as it is a R&R project. P3 and P4 involved a particularly large *number of stakeholders (ES1),* including municipalities, (railway) operators, and commercial users. *Variety of stakeholder perspectives (ES2)* was also prominent in those projects due to the conflicting interests of different parties. *Political influence (ES4)* was mentioned in the ERTMS program due to its long duration and national-level scale.

R&R specific complexity

While the previously described complexity elements are already applicable to R&R projects, additional interview questions revealed into R&R specific complexity. These aspects reflect complexity that arises specifically from working within existing, ageing infrastructure systems and under operational conditions.

In P1 (GP BVL), the tender manager explained that although individual projects in the program are not highly complex on their own, the broader challenge lies in the large-scale replacement of overhead lines across the country. This requires optimization of execution across many locations and timeframes. Innovation in methods and techniques is considered to be essential for scaling up the output. This is related to *experience with technology (TE2)* and *uncertainty in methods (TT4)* within the TOE framework. Additionally, strict quality requirements were mentioned: after renewal works, track stability must remain fully compliant. This related to the element *quality requirements (TS3).*

In P2 (ERTMS), both the project and tender manager emphasized that the existing signaling system must remain fully operational until the new system is operational. This involves building a new system alongside the operational system, while working within limited possession periods (TVPs). This creates complexity linked to *interference with the existing site (EL1).* Like in P1, high *quality requirements (TS3)* were critical, as the new system must be as good as the existing signaling system.

In P3 (IJ-Viaduct), the project had to be delivered under time pressure, with very limited room for delay. This was further complicated by *uncertainties in scope (TS2).* According to the project manager, successful delivery depended heavily on the contractor's leadership and ability to align all parties involved, including subcontractors and external stakeholders. This reflects elements of organizational complexity, particularly *project drive (OS4)* and *dependencies between tasks (TT3).*

In P4 (Schiphol Tunnel), the scope was not completely certain, and the project success depended on numerous stakeholders. Therefore, ProRail opted for a two-phase construction team contract. *Uncertainties in scope (TS2), variety of stakeholders' perspectives (ES2)* and *project duration (OS1*) were mentioned as the most important reasons to choose a two-phase contract. This allowed for early contractor involvement to assess and manage risks together. The interviewees explained that collaboration and proactive risk identification together with the contractor was essential because of safety issues, phasing challenges and multiple stakeholder interests.

To include the contractor's perspective on project complexity and their views on the selected award criteria, interviews were conducted with tender managers from the contractor's side.

4.2.2 Contractor's perspective on project complexity

The contractor's perspective on complexity is included to strengthen the understanding of the complexity of each project. This information is compared with the insights of the interviews at ProRail to figure out whether both perspectives on project complexity are in line with each other.

P1 (GP BVL) was not perceived as technically complex by the contractor. Instead, the complexity was primarily related to the working methods, planning, and execution within strict constraints. This type of challenge can be linked to organizational complexity. This was in line with the perspective of the client that emphasized that these projects are individually not complex, but the complexity lays in how to increase the market output despite the limited capacity.

In contrast, P2 (ERTMS) was considered to be technically much more complex. This was not due to the physical installation of cables or equipment, but due to dependencies between tasks and technical process, system integration, and parallel operational activities. The complexity was mainly in the alignment with existing systems, which corresponds to TOE elements such as *interference with the existing site (EL1)* and *interrelations between technical processes (TT5)*. These issues were in line with those mentioned by the client.

For P3 (Renovation IJ-Viaduct), the complexity was described as the uncertainties in the scope, strict time constraints, strict planning, and intensive interaction with stakeholders and the surrounding environment. These aspects were largely in line with those identified by the client. Early in the process, certain decisions on risk allocation had to be made, and a provisional sum was added to reduce the contractor's exposure to unforeseen issues. This is an example of the margin of safety approach as described by Emblemsvåg (2020).

The interviewee for P3 also stated that, given the uncertainty and risk of unexpected works, a collaborative two-phase contract would have been suitable for this project. The ProRail tender manager also mentioned that this option was considered. However, due to the urgent timeline and the need to obtain a final price quickly, the client ultimately opted for a traditional contract model.

For project P4 (GOS), it was indicated that the project was highly complex in technical, organizational, and external terms. The technical complexity involved the special track structure and overhead line system that had to be replaced. Organizationally, it was challenging due to the tight schedule in combination with the size of the location, which led to logistical difficulties. Environmentally, the project was complex because of the coordination required with many stakeholders, each with their own interests, and the specific location of the project (inside a tunnel). The contractor stated that, due to these multiple complex aspects, early involvement was necessary to start finding solutions sooner and with both client as contractor together. A traditional contract would likely have led to significantly more time being spent by ProRail to figure out these solutions without the expertise of a contractor.

4.2.3 Award criteria selection

The selection of award criteria is an important and strategic step in the procurement process. Based on interviews with several ProRail tender managers, a number of underlying considerations were identified that provide insights into how award criteria are formulated, and which types of project complexity are translated into criteria. These findings help to better understand how ProRail designs its tenders, and contribute to answering the main research question. In Appendix C, a step-by-step approach is presented based on the considerations found.

Balancing requirements and award criteria

In multiple interviews, it was explained that each project has a contracting plan that describes how the risks and responsibilities are divided between ProRail and the contractor. When strict requirements are set, ProRail also takes responsibility for their feasibility and accepts that contractors will reflect these requirements in their pricing. In practice, however, ProRail sometimes retains responsibility for certain requirements, while still expecting contractors to show added value or flexibility on the same aspects. This means that the client sets the boundaries but still creates space for differentiation.

A key consideration here is whether ProRail wants to maintain full control over a specific element of the project. If this is the case, it is specified as a requirement. This trade-off was mentioned in several interviews on both the client and contractor side. Especially in the technical domain, almost all aspects are prescribed by ProRail. This is mainly due to the need for standardized systems across the railway network, which must be extensively tested before implementation. This strict control leaves little room for innovation or differentiation in the technical domain. As a result, interviewees from both client and contractor indicated that most of the distinctive capability lies in the organizational and environmental aspects of a project, which is in line with the identified award criteria.

Translating project complexity and organizational ambitions into award criteria

As presented in the conceptual model, award criteria can be based on two things: organizational ambitions (e.g. policy goals) or project goals, which could be related to complexity. Several tender managers stated that in practice, project goals are considered first, and ProRail's broader ambitions are only taken into account afterwards. This shows a bottom-

up approach: award criteria are first aligned with project-specific needs, and later with general ambitions.

This means that complexity-driven criteria are prioritized in the procurement process, as long as the complexity of the project justifies them. However, in many R&R projects this is not the case. Several interviewees confirmed that most of the R&R projects are still procured using ambition-driven criteria only, such as CO_2 and safety-related scores, and that specific quality criteria are often not needed to select the most suitable contractor.

It was mentioned that an important consideration in selecting award criteria is whether there is enough potential for differentiation between bidders. If not, the criterion is likely to be excluded. As mentioned, the CO_2 Performance Ladder and the Safety Culture Ladder are standard parts of ProRail policy and are included in almost every tender. Additional complexity-driven criteria are considered a project-specific decision and are only included if the project actually involves relevant complexity, such as risks, uncertainty, or stakeholder challenges. If this is not the case, quality criteria will mainly reflect organizational ambitions, and the award decision will be mostly based on price.

Interpreting collaboration as an award criterion

Collaboration was included as an award criterion in 3 out of the 4 analyzed projects. This was also mentioned by multiple interviewees as an important aspect in projects with high uncertainty during tendering. According to both ProRail and contractor representatives, good collaboration between client and contractor, and with external stakeholders, is crucial for success in such projects.

However, the interviews also revealed that collaboration is assessed very differently between projects. Contractors indicated that it is difficult to understand what exactly is expected from them, since there is no consistent assessment method. This makes it harder to optimize their proposals or improve their strategies over time. ProRail interviewees also confirmed that the current assessment of collaboration is not ideal, and that more consistency and clarity would be beneficial.

Influence of contract type on award criteria

Several interviewees mentioned that the contract type is related to the complexity of the project and influences how award criteria are used. For example, in UAV-GC contracts, many responsibilities are assigned to the contractor and the requirements are more strictly defined. In project 4, where a high level of uncertainty was expected, ProRail chose a two-phase (construction team) contract, allowing more flexibility and cooperation.

Interestingly, the document analysis shows that the contract type does not strongly determine which award criteria are included. All types of criteria, both ambition-driven and complexity-driven, were found in both UAV-GC and construction team contracts. The main difference lies in how the criteria are assessed:

- In UAV-GC contracts, contractors are expected to submit detailed and fully developed plans in their bids.

- In construction team contracts, the focus is more on the proposed approach and how the contractor will deal with certain topics during the development phase together with ProRail.

The finding that contract type does not play a decisive role in the selection of award criteria is consistent with the insights obtained from the interview with the tender manager of Project 3

(IJ-Viaduct). Although this project was formally tendered under a traditional UAV-GC contract, the project approach incorporated several elements typically associated with a construction team setting, such as collaborative planning and the sharing of responsibilities.

This observation indicates that the contract form does not unilaterally determine the nature or content of the award criteria applied. Instead, the formulation and application of award criteria appear to be primarily driven by the client's strategic intentions and the specific characteristics of the project context.

5. Discussion

The discussion chapter describes the interpretation of the results and the link to existing literature. Also, the research validation and research limitations are described. The final section discusses suggestions for further research.

5.1 Interpretation of the results

A comparison of the document analysis and interview data reveals a clear relationship between perceived project complexity and the share of complexity-driven award criteria in the tender. In general, the more complex a project is considered to be, the greater the proportion of project-specific award criteria compared to price- or ambition-related award criteria.

Project 1 was regarded as relatively simple by both ProRail and the contractor. This is reflected in the low share of complexity-driven criteria (27%). Project 2 was seen as slightly more complex, mainly due to the implementation of a new technology and limited experience in the market, which led to a 30% share of project-specific criteria. Project 3 showed a more significant rise to 40%, in line with its higher perceived complexity. The complexity in this project was high due to uncertainty in the scope, dependencies between tasks, a high number of stakeholders, and limited flexibility in the execution schedule. Project 4 stood out as the most complex, and nearly the entire award decision was based on project-specific (complexity-related) criteria. Here, price or ambition-based elements played only a minimal role.

What made Project 4 different was the type of tender. Instead of asking the market to carry out a fully defined project, ProRail looked for a contractor who could help find a suitable solution to a complex issue. As confirmed during the validation, such projects result in a shift in procurement focus: from price and efficiency towards quality and problem-solving.

An analysis of the perceived complexity across the four projects (see Table 5) shows that uncertainty in scope and dependencies between tasks are key drivers of project complexity, particularly in projects 3 and 4. While project duration played a role in all the projects, its effect varied. In projects 1 and 2, the long duration was seen as complex due to uncertainties on the long term. In contrast, projects 3 and 4 were challenging due to short execution periods. This is in line with the concept of operational constraints, as described by Kemmer (2018). The number of stakeholders was also cited as a contributing factor to complexity, especially in projects 3 and 4, which were located in dense urban areas. As stakeholder coordination becomes more demanding, perceived complexity increases. In all four cases, interaction with existing infrastructure was mentioned as an additional driver of complexity. This was an expected outcome, because R&R projects are always embedded in the existing environment and often need to be executed while keeping surrounding infrastructure operational.

Overall, the interview results show that complexity increases with the presence of execution-related elements, such as conflicting stakeholder interests, task interdependencies, or limited information about asset conditions. These risks are often addressed through award criteria focused on risk management, stakeholder coordination, and execution planning. In situations where uncertainty makes it impossible to establish a reliable fixed price in advance, ProRail tends to opt for a two-phase contract (project 4). In such cases, the first phase is awarded almost entirely based on quality. During the validation, it was mentioned that although in theory the two phases could be procured separately, this is practically difficult at ProRail due to predetermined train-free periods (TVP), which are scheduled several years in advance. This makes it essential to agree on market-conform prices early in the process, to ensure a fair and feasible project in the realization phase.

In contrast, for projects 1,2 and 3, where ProRail was looking for the most suitable contractor to carry out a predefined project, the analysis shows that the presence of project-specific criteria does not always determine the award outcome, because price remained the dominant factor. This was underlined by the limited room for differentiation in quality criteria. Although distinctive capability was not the main focus of this research, all contractor participants noted in interviews that ProRail's quality criteria often offer little room to stand out. In several interviews, it was noted that the solution space for award criterion proposals is limited due to the extensive set of prescribed requirements defined by ProRail. Additionally, the way in which the award criteria are evaluated constrains the ability of contractors to distinguish themselves. As a result, the quality assessment may have limited influence on the final award decision, and price still plays a leading role. But when nearly 100% of the award decision is based on quality, as in Project 4, price becomes secondary.

5.2 Research validation

This research provides findings that offer insights into both the weighting of complexity-related award criteria per project and the perceived complexity of each individual case. These two types of findings are essential to answer the main research question. The validation supports the relevance of the research findings, but also mentions that conclusions could only be drawn for a very specific group of R&R projects.

It is validated that the results could be considered representative for R&R tenders in which both ambition-driven and project-specific quality criteria have been applied. However, many of ProRail's R&R projects are awarded solely based on price and standardized ambition criteria, in line with current procurement policy.

For a lot of R&R projects, standard award criteria are used to select the most suitable contractor. These are CO2 performance ladder, Safety Culture Ladder, MKI and/or Zero Emission. It is not common to include specific quality criteria in the award decision. Therefore, the four selected projects are not representative for all the R&R projects at ProRail. However, this research focuses on R&R projects that include MEAT criteria, that are related to project specific risks. It is validated that the selected award criteria for these tenders should align with specific project goals. On that scope level, these projects and award criteria are representative, but these projects remain exceptions of the standard R&R tenders. As a result, the findings are not automatically generalizable to all R&R projects within ProRail, but only to those that include also project-specific criteria due to the complexity of the project. Further research could compare these insights with the standard R&R projects.

The findings of the interviews can be considered reliable due to the use of triangulation. The assessment of project complexity is based on insights from three perspectives: a ProRail tender manager, a ProRail project manager, and a tender manager from the involved contractor. This triangulation strengthens the validity of the complexity assessment.

In addition, the expert validation confirmed that complexity-related award criteria often have limited influence on the final award decision. The ProRail tender manager emphasized that price often remains a key factor in the procurement strategy. Contractors are therefore encouraged to submit competitive bids that combine strong pricing with solid quality plans. Focusing solely on quality or on price is unlikely to lead to a successful tender outcome.

5.3 Scientific contribution

The findings of this research align with the literature by Eriksson (2017), which describes that the chosen procurement strategy should correspond to the characteristics of the project. Eriksson states that complex projects are ideally procured using the MEAT principle (Most

Economically Advantageous Tender), allowing quality aspects to be considered alongside price in selecting the most suitable contractor. This principle is also applied in ProRail's procurement practice.

Bergman and Lundberg (2013) also emphasize that complex projects are better awarded based on MEAT criteria rather than price alone. For simpler and more straightforward projects, however, a price-focused approach is considered more effective. Based on this literature, one could argue that in Project 1, which was not perceived as complex, the share of quality-related criteria should not have been as high as approximately 80%. For such projects, a heavy emphasis on quality criteria may not be justified. However, during the contractor interviews it was mentioned that ProRail tenders often offer little room for differentiation on quality criteria. This results in the bidding price being the decisive factor in award decisions. This means that although 80% of the award decision is based on quality, the contract is still awarded mainly based on the bidding price.

Furthermore, the types of project complexity identified in this study correspond with the forms of complexity described by Kemmer (2018). Although Kemmer's research focused more broadly on refurbishment projects rather than specifically on infrastructure renewal, the typology and insights he presents appear to be highly applicable to the replacement and renovation projects investigated. While Kemmer (2018) provides a valuable analysis of the inherent complexity of refurbishment projects and the need for adaptive management approaches, his work does not address how such complexity is reflected in award criteria. This study complements his findings with an empirical analysis to what extent project complexity is translated into award criteria in the context of R&R tenders at ProRail that include project-specific quality criteria. As this represents a small niche within the field of public procurement, further research is recommended to obtain more generalizable insights.

5.4 Reflection on research methodology

This study used a qualitative case study approach to explore how project complexity is reflected in the selection of award criteria within a public contracting organization (ProRail). Four R&R projects were analyzed to gain both detailed insights and the ability to compare patterns across cases.

Case studies were appropriate because they allow researchers to study complex topics within their real-life context, especially when the boundaries between the subject and its environment are not clear (Yin, 2018). A cross-case analysis was added to identify patterns and differences between the projects, helping to understand whether decisions on award criteria were consistent or project-specific (Eisenhardt, 1989).

Semi-structured interviews were used to explore the reasoning behind the chosen award criteria. This method allows flexibility in following up on relevant topics during the conversation, which is helpful when studying complex issues (Kallio et al., 2016). Document analysis of tender materials helped link the qualitative interview data to the actual weighting of award criteria.

To improve the reliability of the findings, data triangulation was applied by combining interviews and document analysis. This strengthened the conclusions by providing multiple perspectives and reducing the risk of bias (Stake, 1995). Overall, the chosen methodology fits well with policy-oriented research, as case studies are known to produce useful, context-specific knowledge for real-world decisions (Flyvbjerg, 2006).

5.5 Limitations of the research

While the study offers valuable insights, there are several limitations to this research. First, the research examined only four R&R projects at ProRail, which raises questions about generalizability of the results. These cases were carefully chosen and do fit the definition of R&R projects, but after the validation, it became clear that most of the R&R projects at ProRail are tendered by only focusing on standard ambition driven award criteria and no project-specific award criteria. It was confirmed that these results are only representative for R&R projects that include project-specific award criteria. However, these are very limited at ProRail.

Another limitation of this study is that it focuses solely on ProRail as a single case. Since no external validation was conducted, it remains uncertain to what extent ProRail's approach to award criteria is representative of other public clients involved in the Dutch R&R task.

With such a small sample, the findings may lean heavily on the particular characteristics of those four projects. The limited number of cases (4) and interviews (12 in total) means that some perspectives may not have been captured. Also, the perception of the project complexity could have been different when other projects were selected or other participants were interviewed. Due to its subjective nature, as described in the literature, it is difficult to assign a specific level to project complexity. ProRail’s project portfolio is broad, and the award criteria, but also the price-quality ratio and the evaluation method, might differ for projects outside of the scope of this research.

Furthermore, it is not validated if new-construction projects from ProRail differ a lot in award criteria from R&R projects. While there are other elements for R&R projects than for new construction projects that contribute to project complexity, it is not analyzed if other award criteria are used by ProRail for awarding the new construction contracts. Also, new construction projects are probably related to the railway network, thus these projects should also be carried out within a certain timespan (TVP). Therefore, some risks could be the same for both new-construction projects as R&R projects. A broader comparison between these type of projects within ProRail could be an interesting suggestion for further research.

Lastly, the table (Table 5) including identified elements that contribute to complexity is only based on the elements that were mentioned in the interviews. This does not mean that other elements from the TOE framework did not contribute to project complexity, but these elements were the most relevant according to the participants’ perspectives. There is a chance that the mentioned elements were already linked to the used award criteria for that project, because in the mail to the participants the topic of this research was described.

5.6 Suggestions for further research

Based on the insights of this research, several suggestions for further research are proposed.

Explore the relationship between award criteria and project performance
This study found that perceived project complexity generally aligns well with the use of project-specific award criteria at ProRail. In more complex projects, the weighting of these criteria is higher than in less complex ones. However, a stronger focus on project-specific criteria does not necessarily mean that project complexity is better managed in practice. Future research could explore the actual impact of these criteria and examine to what extent both the use and the way the award criteria are formulated influence the ability to manage complexity during project execution. In other words, further research could explore what the relationship is between award criteria and project performance.

Broaden the set of projects
This research was based on four ProRail R&R projects, which provided valuable insights into how project complexity is reflected in award criteria. However, expanding the study to include a broader set of R&R projects could strengthen the findings and allow for deeper comparisons. Analyzing differences in award strategies and outcomes across a wider variety of project types (different scale, contract types, level of complexity) could offer a more comprehensive understanding of how complexity is translated into award criteria in practice.

Compare with other public authorities
The findings of this study are specific to ProRail's procurement practices. To explore how representative these practices are for the Dutch public sector as a whole, future research could apply a similar approach to another public authority, such as Rijkswaterstaat. By identifying and comparing the award criteria, weightings, and perceived project complexity in their tenders, it would be possible to assess similarities and differences in how complexity is handled across organizations, potentially revealing broader patterns or organization-specific practices.

Investigate the evaluation method
This research highlighted that even when significant weights are assigned to quality criteria, their influence on the award decision can be limited if there is little room for contractors to distinguish themselves. Future research could focus on the design and functioning of the bid evaluation method itself. A deeper analysis to change the scoring systems may help ProRail to create more differentiation in a fair and transparent way. This could include identifying internal and external barriers for changing the evaluation method. It would also be valuable to compare evaluation approaches across various public authorities in the Netherlands, such as Rijkswaterstaat, provinces, municipalities, and water boards, to identify best practices and opportunities for improvement.

6. Conclusion

This research investigates how ProRail applies award criteria in the procurement of Replacement & Renovation projects, and to what extent those criteria reflect the complexity of the projects. Through a combination of literature review and four in-depth case studies, the study examined the link between project complexity and tender award decisions, which is based on quality criteria and price. The findings provide answers to the research questions and underscore the overall insight:

There is a positive relationship between project complexity and the use of complexity-driven award criteria at ProRail: the more complex the project, the greater the emphasis on project-specific award criteria. However, a clear distinction exists between projects where ProRail requests the realization of a project (P1–3) and those where it invites contractors to help solve a problem (P4).

Part 1: Literature research

During the literature research, it became clear that public clients like ProRail play a dual role in R&R procurement: they must safeguard public interests (such as safety, sustainability, and efficient use of funds) while making sure that projects are delivered effectively (SQ1). Award criteria play an important role in this process, because quality aspects of bids could hereby also be rewarded instead of only award projects based on the bidding price. This way, the interests of a client could be prioritized and translated into the selection process of the best suitable contractor (SQ2).

In theory, there is a strong rationale to link these award criteria to project complexity, so that clients can challenge contractors on how to mitigate certain risks. These risks are the result of uncertainty that comes from project complexity (SQ3). Challenging contractors on how to mitigate risks is crucial for a successful project delivery, particularly in complex R&R projects where operational constraints, stakeholder interests, interdependencies between tasks, and uncertainty in scope or asset condition play a significant role. The literature indicated that it is desirable to align the procurement strategy with project complexity.

Part 2: Empirical study – ProRail (case studies)

The empirical findings show that ProRail partially translates project complexity into project-specific award criteria, and that the degree of translation corresponds reasonably well with the perceived level of complexity. In projects 1 and 2, the weight of project-specific criteria was 27% and 30% respectively, which is relatively low, but in line with the perception that these projects were not particularly complex. Project 3 involved greater complexity, including uncertainty in the technical condition of assets, unclear scope, multiple stakeholders, and limited execution time. This was reflected in a higher weighting of project-specific criteria (40%). In contrast, project 4, which was perceived highly complex by both client and contractor, was awarded almost entirely based on project-specific criteria. This shows a strong alignment between complexity and award criteria. (Q5)

Furthermore, the research shows that technical complexities, such as newness of the technology or interrelations between technical processes, were rarely directly reflected in award criteria. ProRail tends to handle those via strict requirements and leaves little room for contractors to propose alternatives. Instead, most award criteria are linked to organizational or environmental complexity, such as minimizing disruption to rail operators and surrounding communities during construction (Q4).

This is strengthened by the qualitative insight that translating project complexity into award criteria is not straightforward for ProRail. For each project, the project team must weigh several

considerations before deciding to include criteria that address complexity-related risks. It is not only a question of whether ProRail wants to challenge contractors on certain risks, but also whether they are prepared to accept and reward distinctive solutions if contractors offer them. This is particularly relevant within the highly regulated railway sector, where standardization and safety requirements often limit flexibility (SQ6).

In summary, ProRail does not fully translate all the complexity of a project into award criteria, but based on this analysis there is a good match between the complexity of a project and the used award criteria. In more complex projects, the award criteria clearly assess more project-specific risks.

6.1 Recommendations

Stimulate differentiation between contractors
Although this research concludes that the perceived complexity of a project is in line with the complexity-driven award criteria, this does not necessarily that the assigned percentages have a proportional impact on the final award decision. In all the contractor interviews, it was mentioned that ProRail's award criteria often offer limited room for differentiation between contractors. Several reasons for this where identified. First, the solution space is perceived as small, which leaves little possibilities to propose innovative or distinctive plans. This is due to all the prescribed specifications by ProRail. Furthermore, the evaluation method used for MEAT criteria offers limited differentiation due to the way contractor proposals are evaluated and scored. Also, it was mentioned that in some cases the maximum scores are relatively easy to achieve, resulting in no distinctive capability for contractors. When there is little distinctive capability for contractors on quality criteria, the bidding price will be the decisive factor although on paper quality criteria are weighted high. A good example of this is project 1, where on paper 80% of the award decision is based on quality criteria and only 20% on price. However, still the contractor mentioned that for this project, price was the decisive factor.

As mentioned in the literature research, awarding on price has several downsides. Therefore, to increase the effectiveness of quality-based award criteria, ProRail could consider refining the evaluation method, for example by applying an exponential scale or a relative scoring method. However, relative scoring could lead to rank reversal (Schotanus et al., 2022), which will probably lead to more legal dispute, which is something ProRail naturally wants to avoid in order to keep procurement processes smooth and efficient. Rank reversal could be prevented by adding a reference value. In that way, relative scoring could still be applied, for example for award criteria where the maximum score is sometimes relatively easy to reach, such as the MKI score or Zero Emission score. Additionally, ProRail could consider raising the threshold for maximum scores to make them more challenging to achieve and thereby encourage contractors to deliver more ambitious proposals. This could also be applied to criteria such as the Safety Culture Ladder and the CO_2 Performance Ladder.

Communicate expectations clearly to the market
Because contractors are always looking for the best strategy to win a contract, it is important that their strategies align with the expectations of the client. To support this, the purpose of each award criterion, but also ProRail's overall goal for the project, should be clearly communicated. This research found that sometimes the contractor's strategy did not align with ProRail's objectives. In interviews with ProRail, it was mentioned that not every project is suitable for innovative or experimental solutions. In some cases, ProRail simply wants clear, practical plans at a competitive price, rather than innovation that may come at the expense of cost efficiency. It is therefore crucial that the project's goal and the purpose behind specific quality criteria are transparent to the contractor. This helps prevent contractors from wasting effort or focusing on aspects that do not reflect ProRail's priorities.

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Appendices

Appendix A: Interview guides

As part of the data collection, semi-structured interviews are conducted with both client participants as contractor participants for each case. At the client's side four interviews were conducted with project managers and four interviews were conducted with tender managers. At the contractor's side four interviews were conducted with tender mangers. In total 12 (4x3) interviews were conducted. Three different guides for the semi-structured interviews were used: one for the project manager of ProRail, one for the tender manager of ProRail and one for the tender manager of the contractor. These guides'(Dutch) are presented below.

Table: Interview guide tender manager (Dutch)

Interview Tendermanager			
Bedrijf		ProRail	
Naam		X	
Functie		Tendermanager	
Ervaring		X	
Doel interview		Begrijpen hoe de tendermanager keuzes maakt bij het opstellen en wegen van gunningscriteria en hoe complexiteit daarbij een rol speelt	
Project		X	
Onderwerp		**Vraag**	**Toelichting**
Inleiding		Kunt u uw rol als tendermanager binnen dit project kort toelichten?	Inleiding
Uitdagingen project	1	Wat waren de voornaamste uitdagingen in dit project?	Project specifiek
	2	Hoe wordt er rekening gehouden met uitdagingen op het gebied van vervanging- en/of renovatie?	Project specifiek
Gunningscriteria	3	Wat is in uw ogen het doel van het gebruik van gunningscriteria?	Algemeen
	4	Hoe wordt binnen uw team bepaald welke gunningscriteria worden gehanteerd?	Project specifiek
	5	Hoe worden projectdoelstellingen vertaald naar specifieke gunningscriteria? Zijn er vaste richtlijnen of gebeurt dit per project anders?	Algemeen
	6	Hoe bepaalt de beschikbaarheid en concurrentie in de markt (beperkt aantal spooraannemers) welke gunningscriteria je kan uitvragen?	Algemeen

Weging gunningscriteria	7	Hoe wordt de prijs-kwaliteit van een project bepaald voor het wegen van criteria?	Algemeen
	8	Hoe wordt bepaald op welke criteria in een aanbesteding de nadruk ligt (wegingen)?	Algemeen
Afweging complexiteit en ambities	9	Wordt bij het selecteren van gunningscriteria een afweging gemaakt tussen projectdoelstellingen (beheersen complexiteit) en organizatorische ambities? Zo ja, hoe wordt die afweging gemaakt?	Algemeen
	10	*project specifieke vragen*	Project specifiek
	11	*project specifieke vragen*	Project specifiek
	12	*project specifieke vragen*	Project specifiek
Markt stimuleren V&R	13	Zijn er V&R specifieke uitdagingen waarop jullie de markt met gunningscriteria zouden willen prikkelen?	Algemeen
Onderscheidend vermogen	14	Wordt in het opstellen van de gunningscriteria ook gekeken naar het onderscheidend vermogen voor aannemers? Heeft ProRail van tevoren een beeld van het onderscheidend vermogen dat aannemers kunnen benutten?	Algemeen
Koppeling uitvoering	15	In hoeverre hebben de gehanteerde gunningscriteria in dit project geleid tot het gewenste resultaat? Hoe zouden gunningscriteria in uw ogen nog beter kunnen worden ingezet?	Project specifiek
Toekomstgericht	16	Is de huidige manier van aanbesteden (project gericht) volgens u de beste manier om vervanging of renovatie projecten door de markt te laten uitvoeren? Wat zou er in uw ogen beter kunnen?	Slot
	17	Op welke gebieden verwacht u dat gunningscriteria in de toekomst gaan veranderen? En wat is hiervoor de aanleiding?	Slot
Extra	18	Wanneer is een project succesvol in uw ogen? Spelen gunningscriteria hier een grote rol in?	Slot

Table: Interview guide project manager (Dutch)

Interview projectmanager			
Bedrijf		ProRail	
Naam		X	
Functie		Projectmanager	
Ervaring		X	

Doel interview		In kaart brengen hoe de projectmanager de complexiteit van het project ervaart en welke rol gunningscriteria hebben in het beheersen van complexiteit	
Project		X	
Onderwerp		**Vraag**	**Algemeen of specifiek**
Inleiding		Kunt u uw rol als projectmanager binnen dit project kort toelichten?	Inleiding
Uitdagingen project	1	Hoe worden aan de voorkant van projecten de uitdagingen of complexiteit van een project geïdentificeerd?	Algemeen
	2	Wat waren de voornaamste uitdagingen in dit project?	Project specifiek
	3	Hoe wordt er rekening gehouden met de specifieke uitdagingen op het gebied van vervanging- en/of renovatie?	Project specifiek
	4	Hoe wordt ook rekening gehouden met de onzekerheid over de staat van het te vervangen object?	Project specifiek
	5	Komt de zojuist beschreven complexiteit van het project terug in de aanbesteding van dit project?	Project specifiek
	6	Zo ja, op welke manier? In de vorm van gunningscriteria of wordt complexiteit op andere manieren beheerst zoals via eisen of de contractvorm? Praktijkvoorbeelden?	Project specifiek
	7	**project specifieke vraag**	Project specifiek
	8	**project specifieke vraag**	Project specifiek
	9	**project specifieke vraag**	Project specifiek
Gunningscriteria	10	Wat is in uw ogen het doel van het gebruik van gunningscriteria?	Algemeen
	11	Hoe worden projectdoelstellingen vertaald naar specifieke gunningscriteria? Zijn er vaste richtlijnen of gebeurt dit per project anders?	Algemeen
Gunningscriteria weging	12	Hoe wordt bepaald op welke criteria in een aanbesteding de nadruk ligt (wegingen)?	Algemeen

	13	Wordt bij het selecteren van gunningscriteria een afweging gemaakt tussen projectdoelstellingen (beheersen complexiteit) en organizatorische ambities? Zo ja, hoe wordt die afweging gemaakt?	Algemeen
	14	Hoe bepaalt de beschikbaarheid en concurrentie in de markt (beperkt aantal spooraannemers) welke gunningscriteria je kan uitvragen?	Algemeen
Koppeling naar uitvoering	15	In hoeverre hebben de gehanteerde gunningscriteria in dit project geleid tot het gewenste resultaat? Hoe zouden gunningscriteria in uw ogen nog beter kunnen worden ingezet?	Project specifiek
	16	Hoe ervaart u als projectmanager de aansluiting tussen de gunningscriteria en de daadwerkelijke uitvoering in dit project?	Project specifiek
Toekomstgericht	17	Is de huidige manier van aanbesteden (project gericht) volgens u de beste manier om vervanging of renovatie projecten door de markt te laten uitvoeren? Wat zou er in uw ogen beter kunnen?	Slot
	18	Op welke gebieden verwacht u dat gunningscriteria in de toekomst gaan veranderen? En wat is hiervoor de aanleiding?	Slot
Extra	19	Wanneer is een project succesvol in uw ogen? Spelen gunningscriteria hier een grote rol in?	Slot

Table: Interview guide tender manager contractor (Dutch)

Onderwerp		Vraag	Toelichting
Complexiteit	1	Hoe zou u de complexiteit van dit project omschrijven als opdrachtnemer? Welke technische, organisatorische of omgevingsfactoren speelden een rol?	Specifiek
	2	In hoeverre vond u dat de opdrachtgever een goed beeld had van de complexiteit/uitdagingen van het project tijdens de aanbesteding?	Specifiek
Gunningscriteria	3	Hoe heeft u de gunningscriteria voor deze aanbesteding ervaren?	Specifiek
	4	Had u het idee dat u als aannemer de middelen had om goed in te spelen op de gestelde gunningscriteria?	Specifiek
	5	Was het achteraf voor uw organisatie duidelijk hoe de opdrachtgever de gunningscriteria interpreteerde en welke aspecten belangrijk waren?	Specifiek

	6	Zijn er uitdagingen in het project waarin je als aannemer de opdrachtgever goed zou kunnen helpen, maar die niet zijn teruggekomen als gunningscriterium?	Specifiek
	7	Heb je een idee dat de gunningscriteria van ProRail goed doorgronden of een aannemer begrijpt aan welk project hij begint?	Algemeen
Onderscheidend vermogen	8	Was er in uw ogen voldoende ruimte gecreëerd door de opdrachtgever om je als aannemer te onderscheiden?	Specifiek
	9	Welke criteria ervaren jullie als het meest uitdagend om goed op te scoren? Ambitie of complexiteit beheersing?	Specifiek
	10	In hoeverre stimuleren de gunningscriteria van ProRail innovaties in de markt?	Algemeen
	11	Wat zou ProRail kunnen doen om innovatie beter te stimuleren in hun gunningscriteria?	Algemeen
Toekomstgericht	12	Ziet u een verschuiving in hoe opdrachtgevers complexiteit verwerken in aanbestedingen? Verwacht u dat dit in de toekomst gaat veranderen?	Algemeen

Appendix B: Coding scheme

This appendix provides an overview of the coding scheme that was used during the thematic analysis of the interview transcripts. The coding of the interviews improved the understanding of the use of award criteria by ProRail, but helped to group other information related to project complexity and the procurement process. The codes were developed using both deductive and inductive approaches. Deductive codes were derived from the theoretical framework and research questions, while inductive codes emerged during the analysis based on recurring patterns in the interviews. Three overall themes were used: Project complexity, award criteria and procurement process and context.

Thema: Project complexity			
Code	**Subcode**	**In- or deductive**	**#elements**
Beheersen van complexiteit	Beheersen door ProRail (eis)	Deductive	8
	Beheersen via eis	Inductive	27
	Bheersen via gunningscr.	Inductive	38
	Beheersen via IB	Inductive	11
	Onduidelijk hoe te beheersen	Inductive	24
Projecteigenschappen		Deductive	15
Identificeren van uitdagingen		Deductive	14
Onduidelijkheid scope		Inductive	12
Onzekerheid staat van infrastructuur		Inductive	3
Specifieke uitdagingen V&R		Deductive	38
V&R eigenschappen		Deductive	16
Verschil losstaand project en programma		Inductive	5

Thema: Award criteria		
Code	**In- or deductive**	**#elements**
Afweging Eisen en gunningscriteria	Deductive	6
Afweging projectdoelstellingen en ambities	Deductive	20
Ambitie ProRail	Deductive	22
Doel gunningscriteria	Deductive	12
Duurzaamheid	Inductive	16
Vertaling projectdoelen naar gunningscriteria	Deductive	19

Koppeling gunningscriteria en uitvoering	Inductive	14
Gunningscriterium	Deductive	36
Onderscheidend vermogen	Deductive	39
Prijs-kwaliteit verhouding	Deductive	5
Beoordeling door ProRail	Deductive	13
Weging gunningscriteria	Deductive	14
Samenwerking	Inductive	31

Thema: Procurement process and context		
Code	**In- or deductive**	**#elements**
Aanbestedingsproces	Deductive	15
Contract keuze	Deductive	15
Beschikbaarheid markt	Deductive	5
Betrekken aannemer in ontwerp (ECI)	Inductive	4
Richtlijnen	Inductive	2
Ontwikkeling gunningscriteria en manier van aanbesteden	Inductive	18
Aanpak	Inductive	22
Succesvol project	Deductive	11

Appendix C: Interview participant mail

Onderwerp: Afstudeeronderzoek gunningscriteria V&R interview

Beste …,

Mijn naam is Christiaan van der Feltz en ik heb uw emailadres gekregen van …. Momenteel ben ik bezig met mijn afstudeeronderzoek aan de TU Delft en daarvoor ben ik afgelopen weken in contact geweest met …. Dit onderzoek doe ik bij BAM Infra, maar ik focus me nu toch vooral op de opdrachtgever, ProRail. Het onderzoek gaat over de complexiteit van V&R projecten en de vertaling van complexiteit naar gunningscriteria. Gisteren mailde … mij dat ik u daarvoor ook kan benaderen, fijn om te horen!

Voor het onderzoek heb ik 4 projecten van ProRail geselecteerd om op in te zoomen. Per project zou ik de projectmanager en tendermanager graag willen interviewen. De vragen voor de projectmanager zullen ingaan op de “complexiteit” van het project en de vragen voor de tendermanager zullen ingaan op de “gunningscriteria en de redenatie achter de keuze voor bepaalde gunningscriteria”.

Voor het project *(PROJECT INVULLEN)* kom ik graag met u, als *(PROJECTMANAGER/TENDERMANAGER)*, in contact voor een aantal vragen over dit project.
PROJECTMANAGER: De vragen zullen gaan over de complexiteit die u als projectmanager in dit project heeft ervaren en over de rol die u ziet voor gunningscriteria bij het beheersen van deze complexiteit.
TENDERMANAGER: De vragen zullen gaan over het doel van het gebruik van gunningscriteria en het onderscheidend vermogen dat gecreëerd wordt voor aannemers in dit project.

Hiervoor plan ik graag een uurtje in om vragen te kunnen stellen. Zelf mikte ik op de laatste week van februari of de eerste week van maart (24-feb tot 7-mrt), maar het gaat er natuurlijk om of u kan! De interview inzichten zal ik naar u terugkoppelen en natuurlijk anonimiseren. Dit kunnen we later ook nog bespreken.

Super leuk dat u mij wilt helpen! Voor nu hoor ik graag wanneer het goed uitkomt om een uurtje te reserveren. Om even af te stemmen kunt u mij ook altijd even bellen als dat makkelijker is.

Met vriendelijke groet,

Christiaan van der Feltz

Appendix D: TOE framework

In the following figure, the TOE framework is presented, including all the elements. The table is created by artificial intelligence (ChatGPT), based on the paper of Bosch-Rekveldt et al. (2011).

Category	Code	Element defined	Explanation
T	TG1	Number of goals	What is the number of strategic project goals?
T	TG2	Goal alignment	Are the project goals aligned?
T	TG3	Clarity of goals	What is the degree of goal alignment across the project team?
T	TS1	Scope largeness	What is the largeness of the scope, e.g. the amount of deliverables involved in the project?
T	TS2	Uncertainties in scope	Are there uncertainties in the scope?
T	TS3	Quality requirements	Are there strict quality requirements regarding the deliverables?
T	TT1	Number of tasks	What is the number of tasks involved?
T	TT2	Variety of tasks	What is the variety of tasks?
T	TT3	Dependencies between tasks	What is the number and nature of dependencies between the tasks?
T	TT4	Uncertainty in methods	Are the uncertainties in methods used?
T	TT5	Interrelations between technical processes	What is the number and nature of interrelations between technical processes?
T	TT6	Conflicting norms and standards	Are there conflicting design standards and country specific norms in the entire project?
T	TE1	Newness of technology (world-wide)	Do the involved parties have experience with new-to-world technologies?
T	TE2	Experience with technology	Do the involved parties have experience with new-to-company technologies?
T	TR1	Technical risks	Do you consider the project being high risk (number, probability and/or impact of technical risks)?
O	OS1	Project duration	What is the planned duration of the project?
O	OS2	Compatability of different project management methods and tools	Do the involved parties use comparable project management methods or tools?
O	OS3	Size in CAPEX	What is the estimated CAPEX of the project?
O	OS4	Size in Engineering hours	What is the size in Engineering hours needed in the project?
O	OS5	Size of project team	What is the size of the project team?
O	OS6	Size of site area	What is the size of the site area?
O	OS7	Number of locations	How many project sites are involved?
O	ORE1	Project drive	Is there strong project drive?
O	ORE2	Resource and skills availability	Are the resources available?
O	ORE3	Experience with parties involved	Do you have experience with the parties involved?
O	ORE4	HSSE awareness	Are HSSE (Health, Safety, Security and Environment) aspects important?
O	ORE5	Interfaces between different disciplines	Are there interfaces between different disciplines involved in the project?
O	ORE6	Number of financial resources	How many financial resources does the project have?
O	ORE7	Contract types	What are the different contract types involved?
O	OP1	Number of different nationalities	What is the number of different nationalities involved?
O	OP2	Number of different languages	How many different languages were used in the project for communication?
O	OP3	Cooperation JV partner	Do you cooperate with a JV partner?
O	OP4	Overlapping office hours	Do overlapping time zones hinder cooperation?
O	OT1	Trust in JV partner	Do you trust the joint venture partner (if applicable)?
O	OT2	Trust in contractor	Do you trust the contractor?
O	OR1	Organizational risks	Do you consider the project being high risk (number, probability and/or impact of organizational risks)?
E	ES1	Number of stakeholders	What is the number of stakeholders?
E	ES2	Variety of stakeholders' perspectives	What is the variety of stakeholder perspectives?
E	ES3	Dependencies on other stakeholders	What are the dependencies on other stakeholders?
E	ES4	Political influence	Is there political influence?
E	ES5	Company internal support	How strong is the company internal support?
E	ES6	Required local content	Is there required local content?
E	EL1	Interference with existing site	Do you experience interference with the existing site or situation?
E	EL2	Weather conditions	Do you experience difficult weather conditions?
E	EL3	Remoteness of location	Do you experience a remote location?
E	EL4	Experience in the country	Do the involved parties have experience in the country?
E	EM1	Internal strategic pressure	Is there internal strategic pressure from the business?
E	EM2	Stability project environment	Is the project environment stable (e.g., changes in political, legal, financial regulations)?
E	EM3	Level of competition	What is the level of competition?
E	ER1	Risks from environment	Do you consider the project being high risk (number, probability and/or impact of environmental risks)?

Appendix E: Identified ambitions ProRail

In this table, the identified ambitions from the Masterplan 2026-2030 and the Beheerplan 2024-2025 are summarized. The table also includes the corresponding page numbers and a brief explanation of the key aspects. The table is presented in Dutch.

Sleutelwoord / ambitie	Bron (documentnaam)	Pagina	Toelichting
Duurzame mobiliteit	Masterplan 2026 - 2030	7, 8, 9	ProRail wil bijdragen aan duurzame mobiliteit door spooruitbreidingen en onderhoud om meer treinverkeer mogelijk te maken.
Spooruitbreiding	Masterplan 2026 - 2030	13, 14, 15	Projecten zoals het Programma Hoogfrequent Spoor (PHS) en trajectuitbreidingen om de capaciteit te verhogen.
Veiligheid en betrouwbaarheid	Masterplan 2026 - 2030	7, 12, 13	Onderhouds- en vervangingsprojecten gericht op infrastructuurveiligheid en betrouwbaarheid.
Netwerkontwikkeling	Masterplan 2026 - 2030	8, 11, 12, 13	Verbeteringen en uitbreidingen van spoorwegen en stations om de groeiende mobiliteitsbehoefte op te vangen.
Verduurzaming	Masterplan 2026 - 2030	8, 9, 10	Verminderen van ecologische voetafdruk door energiezuinige maatregelen en gebruik van duurzame materialen.
Betaalbaar spoor	Masterplan 2026 - 2030	9, 17, 18	Streven naar efficiënte besteding van middelen en verlaging van kosten per treinpad.
Digitalisering	Masterplan 2026 - 2030	10, 11, 19	Gebruik van data en slimme technologieën voor onderhoud en betere planning van spoorprojecten.
Internationale verbindingen	Masterplan 2026 - 2030	11, 14, 15	Betuweroute-uitbreidingen en de invoering van ERTMS voor verbeterde grensoverschrijdende treinverbindingen.
Meer reizigers- en goederentreinen	Masterplan 2026 - 2030	7, 8, 12, 13	Frequentieverhogingen en infrastructuuraanpassingen om de capaciteit van het spoor te vergroten.
Samenwerking in de sector	Masterplan 2026 - 2030	9, 10, 20	Betere samenwerking tussen stakeholders, vervoerders en

			marktpartijen voor efficiëntere uitvoering van projecten.
Duurzaamheid	**Bron (documentnaam)**	**Pagina**	**Toelichting**
Materiaalgebruik	Beheerplan 2024 - 2025	48	Doelstelling om in 2030 50% van de toegepaste materialen secundair (hergebruikt) te laten zijn en een 50% reductie van de milieukostenindicator (MKI)
Energiereductie	Beheerplan 2024 - 2025	48	Doel om in 2030 30% minder energie te verbruiken dan in 2015, met een focus op wisselverwarming en sanering van wissels.
Energieopwekking	Beheerplan 2024 - 2025	48	In 2030 wil ProRail 150 GWh duurzame energie opwekken op eigen assets.
Netwerkontwikkeling	**Bron (documentnaam)**	**Pagina**	**Toelichting**
Betere punctualiteit en betrouwbaarheid	Beheerplan 2024 - 2025	9	Investeren in preventief onderhoud en slim asset management.
Innovatieve aanbestedingsstrategieën	Beheerplan 2024 - 2025	31	Slimme contracten en betere samenwerking met aannemers.
Digitalisering logistiek	Beheerplan 2024 - 2025	23	Verbetering van verkeersleiding en planning via big data en AI.